SCIENTIFIC REPORTS

OF THE

Imperial Institute of Agricultural Research, Pusa

(Including the Reports of the Imperial Dairy Expert, Physiological Chemist and Sugarcane Expert)

1931-32

DELHI: MANAGER OF PUBLICATIONS
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ERRATA.

Page 25, item 11, line 3, *delete* comma after lb.
„ 26, line 20, for *psoraliodes* read *psoraloides.*
„ 37, „ 29, for *Serghum* read *Sorghum.*
„ 44, „ 1, *for* contd. *read* concld.
„ 69, „ 10 from bottom, for B. *juncea* read *B. juncea.*
„ 75, „ 4, from bottom, read author's name as Shaw, F. J. F.
„ 76, „ 20, for *radiatus L.* read *radiatus* L.
„ 107, „ 4, *for* soll *read* soil.
„ 118, last word in last line is table.
„ 123, line 20, *for* are *read* were.
„ 125, „ 15, *delete* comma after 213.
„ 126, „ 18, for *sticticraspis* read *stricticraspis.*
„ 126, „ 21, for *Emmalocero* read *Emmalocera.*
„ 140, „ 23, *insert* 7 after No.
„ 141, „ 21, for *diatræa* read *Diatræa.*
„ 145, „ 10, *insert* and after Phaloniadae.

Scientific Reports of the Imperial Institute of Agricultural Research, Pusa

(Including the Reports of the Imperial Dairy Expert, Physiological Chemist and Sugarcane Expert)

1931-32

REPORT OF THE DIRECTOR

(W. McRae, M.A., D.Sc., F.L.S., I.A.S.; and F. J. F. Shaw, D.Sc., A.R.C.S., F.L.S., I.A.S.)

I. RESEARCH AND PROGRAMME OF WORK

The Nitrogen Problem

The maintenance of an adequate supply of nitrogen in Indian soils constitutes one of the most important problems before agricultural research workers and is engaging the attention of several Sections of the Institute. The influence of leguminous crops in conserving the soil nitrogen when grown in mixture with a cereal has been tested for the last three years. Though the total nitrogen remaining in the soil at the end of two years is less than at the beginning of the experiment, a gain is noticed in all plots when the nitrogen removed in the crops is taken into account. The highest gain calculated in this way is 265·4 lb. per acre in one series with a mixed crop of maize and *urid* (*Phaseolus radiatus*) grown in the *kharif* (summer) season and 128·9 lb. per acre in the second series with peas and barley grown mixed in the *rabi* (winter) season.

The hope held out in last year's report that *urid*, on account of its cheap seed-rate, may prove a more economical green manure than sann-hemp has not been realized in a large-scale experiment. A field of wheat manured with *urid* yielded a profit of Rs. 16-2-4 per acre as against Rs. 20-8-0 from a field manured with sann-hemp. There was an increase of 100 per cent. in profit when only sann-hemp tops were used as manure and stems were utilized for extracting fibre. Though the latter practice meets the principal

economic difficulty in securing an extension of green-manuring in that the loss of one crop is obviated, the high cost of labour when it is carried out on a large scale is likely to be a handicap to its adoption. The Bacteriological Section is therefore carrying out an experiment on the possibility of securing green manure from land already growing another crop. As in the previous year, but on a larger scale, on land growing onions, Mexican sunflower was also planted. Expressed in yields per acre 169 maunds of onions and 420 maunds of sunflower (sufficient to manure one and-a-half acres of land) were obtained, as against 187·9 maunds of onions from control plots growing that crop alone. When sunflower was tested as a green manure against the same quantity of sann-hemp tops a 10 per cent. greater yield was obtained with the former. A large-scale field trial will be made in the coming season.

The problem of green-manuring is being attacked in the Chemical Section from another direction in collaboration with the Imperial Agriculturist. In years of deficient rainfall it often happens that sann-hemp, although ploughed in at the full time, does not break down properly and is frequently found undecomposed in the land in February. The result is that the *rabi* crop intended to be benefited by the application of green manure is damaged by the heavy incidence of termites. Experiments have therefore been started to determine the amount of water transpired by sann-hemp crops during the period of growth and also the rate of decomposition with different concentrations of moisture. It is also proposed to ascertain whether the addition of a small dose of sulphate of ammonia accelerates the decomposition of the stems and branches.

Mineral Manures

The most economical use of mineral fertilizers and their effect on the soil and the crop is a branch of research which is increasing in importance. As a general rule, in India artificial fertilizers are usually beyond the means of small cultivators and their use in this country is mostly limited at present to crops which are grown on large areas and offer a big money return per acre (*e.g.*, sugarcane, tobacco and rice).

Phosphate. A simple method of disintegrating bones into an easily friable material, which consists in keeping them for about two months in an air-tight vessel containing a mixture of 1·5 per cent. of caustic alkali and 1 per cent. common salt, was reported last year. It has since been ascertained that the cost of preparing alkali-treated bone fertilizer is much less than that of bonemeals or bone superphosphates, and that such fertilizer is superior to both of them in respect to its phosphoric acid content and its effect on crops.

Potash. With a view to finding out whether the depressing effect of potash in Pusa soil, referred to in last year's report, is due directly to potash or to some other indirect cause, such as the inter-

action of the sulphate of potash (the common and cheapest form in which this fertilizer is available and used) with the calcium carbonate present in the soil, plots treated with potassium sulphate, potassium chloride, potassium carbonate and calcium sulphate have been laid out in which *marua* (*Eleusine coracana*) and oats are being grown as *kharif* and *rabi* crops respectively. Since the interaction of potassium sulphate with calcium carbonate gives rise to the formation of potassium carbonate and calcium sulphate, the latter has been also included in the experiment. In experiments designed to determine the relative utility of farmyard manure and sann-hemp with and without artificial fertilizers like superphosphate and sulphate of ammonia with special reference to crop yields and biochemical changes, the limiting values of phosphate and mineral nitrogen causing an increased yield of wheat have been found to be 60 and 100 lb. per acre. On the other hand, no such characteristic limit is evident with *marua* in which case a more or less progressive increase in yield was obtained up to 100 and 160 lb. per acre of these minerals. The effect of manures on the juice of sugarcane is being tested in latin square plots treated with mustard cake alone, and in combination with sulphate of potash or superphosphate or both.

Improving the Soil Conditions

In connection with the work on the physico-chemical characteristics of the alkali soil of Sind about to be put under perennial irrigation, the examination of a typical soil profile of $42\frac{1}{2}''$ depth (divided into 11 layers of depths varying from $3''$ to $6''$) has been concluded in the Chemical Section, and confirmation has been obtained of the statement made last year that under natural conditions the soil is of the " solenetz " type. The striking tendency of the monovalent ions to rise to the surface and the bivalent ions to go downwards has been clearly established, and the existence of a hard gypsum layer has been noted at a depth of $18\frac{1}{2}''$ to $24\frac{1}{2}''$. Determinations of exchangeable bases show that calcium predominates over others and determines the fluctuations of the saturation capacity with depth, that chemical weathering has taken place more vigorously down to a depth of $24\frac{1}{2}$ inches as indicated by the high saturation capacity, that the hard pan layer does not show any extraordinary degree of alkalization and its formation may be due to the accumulation of gypsum, silica and heavy clay, and that considerable alkalization has taken place throughout the whole profile, the respective ratios of the monovalent to the bivalent ions averaging 0·36 as against the maximum of 0·10 in a sweet calcareous soil.

Earlier work having confirmed the inadequacy of the existing laboratory methods as a quantitative measure of the lime requirement of acid soils, pot experiments have been laid down with an acid soil by adding increasing aliquot portions of lime required to bring the pH value of the soil to 7 for periodical examination of soil samples and also for cropping trials.

The Quality of Agricultural Produce

The quality of agricultural produce depends upon its uniformity, its purity and its possession of some intrinsic property, *e.g.*, high gluten content in wheat, oil-content in linseed, disease resistance in pigeon-pea. The spread of pure line seeds by the Agricultural Departments places a uniform product in the hands of the cultivator, and the maintenance of purity in the crop depends on the extent to which it is in the power of the ryot to carry out harvesting and sowing with some approach to modern methods. Improvement in any intrinsic property of a crop is the work of the plant-breeder, and this section of the report is mainly concerned with what is being done at Pusa in this respect.

Wheat. In co-operation with the Department of Agriculture in Sind, milling and baking tests of flour from some wheats bred in the Botanical Section, Pusa, were made in the United States of America. Besides Pusa wheats grown at Pusa and in Sind, Sind wheats grown in Sind were also included in the milling tests. Pusa 114 with a protein content of 15·45 per cent. has proved in these tests to be the best wheat for Sind, while the second place has been taken by Pusa 111 which was also favourably reported on in the milling and baking tests made by the Research Association of British Flour Millers last year. All the available seed of Pusa 114 at Karnal has been purchased by the Sind Agricultural Department.

Barley. Pusa Type 21 distinguished by high yields and plumpness of grain has not proved very suitable for malting and brewing purposes because of the purplish tinge present on the seed surface. Some cross-bred forms studied this year in the F_2 generation however show promise of combining the high yielding power of Type 21 parent and the white colour of the seed of the other parents, and may thus furnish material for producing a good type of malting barley.

Tobacco. As stated in last year's report, the problem of meeting the ever-increasing demand for a lighter and brighter tobacco is being tackled in the Botanical Section which has, by crossing a local type (Type 28) with an American Adcock, evolved 10 hybrids which are now fixed and are breeding pure within narrow limits. Of these, No. 142 has again behaved well under flue-curing in the barn. The Chemical Section is continuing work on the relation of the changes taking place during various methods of curing in the quality of the cured leaf. After having established the superiority of rack-curing over the country custom of ground-curing, the investigation has been extended to the determination of the difference in the quality of the cured leaf when the leaves are picked from the stalk as they ripen and when the whole stalk is cut off near the ground at such time as will give the greatest number of properly ripe leaves. It has already been ascertained that whether an exotic or indigenous variety of tobacco is grown, leaves with stalks on when cured on racks are richer in nicotine content.

They will be examined now for their sugar, starch, and amido and albuminoid nitrogen contents which along with nicotine have been recognized by several investigators as having a direct bearing on the quality of tobacco.

Rahar. The improvement of this crop by the production of types which are resistant to wilt disease has been the result of a joint investigation by the Mycological and Botanical Sections. Several types are now available which appear to possess a high degree of resistance, and among them further investigations are being carried out to determine the type which is most profitable from the point of view of the agriculturist.

In the case of other crops such as oats and sugarcane, the improved varieties evolved are distinguished by the superior quality of their produce, but as their value lies mainly in the higher acreage yields obtained, they are referred to in the succeeding section dealing with improvement of the yield of agricultural produce.

Breeding Improved and Higher Yielding Varieties

The work of breeding high yielding types of Indian crops constitutes an important part of the duties of the Botanical Section and furnishes a source of practical training for the students. The success achieved by the Pusa varieties of crops and by the Coimbatore canes affords a measure of what has been and is being achieved.

Barley. A yield trial was run this year in the Pusa Farm in pairs of contiguous plots with the best type of barley (Type 21) evolved at Pusa and the best form isolated by the United Provinces Department of Agriculture at Cawnpore (Type 251). The results were as follows:—

	Total yields in lb. in 28 pairs of contiguous plots (area of each plot=0·028 acre)	Yield per acre in lb.
Pusa Type 21 . .	1,871·7	2,387
Cawnpore Type 251 .	1,697·4	2,165

Another trial arranged at the Raya Farm in the Muttra District of the United Provinces also yielded results in favour of the Pusa type:—

	Yield per acre in lb
Pusa Type 21	2,610
Cawnpore Type 251	2,511

It must be remembered that at Pusa barley is never irrigated, whereas in the United Provinces three to four irrigations are given.

Oats. A number of promising hybrids obtained by crossing Pusa types with Abundance and Scotch Potato varieties were tried in randomized blocks simultaneously at Pusa (without irrigation)

and Karnal (under irrigation) against the standard Pusa types B.S. 1 and B.S. 2 for which there is a steadily increasing demand of seed owing to their higher yield and better quality as compared with local varieties. Whereas in preliminary trials in the last two years most of the hybrids gave higher yields than B.S. 1 and B.S. 2 oats, the unusually dry season at Pusa during the year under report apparently helped the latter to outyield the hybrids. On the other hand at Karnal, where the crop was irrigated, the hybrids maintained their superiority over the B.S. selections and confirmed the results usually obtained at Pusa in years of normal rainfall. The most promising hybrids are C and J which, in addition to plump grain and good tillering, yield a high quantity of straw. It is proposed to repeat these trials.

Linseed. Some of the hybrids obtained by crossing the high yielding Pusa Types 12 and 121 of low oil-content with certain Central Indian varieties which have high oil-content but low yields were subjected to a yield trial in randomized blocks and latin squares. Though Hybrid 10 did not come up to Type 12 in yield and was placed second in the order of merit, the following figures will show the improvement effected in oil-content.

Table showing the oil-content in linseed hybrids

	1928-29	1929-30	1930-31	1931-32	Mean
Type 12	36·67	36·93	37·68	37·29	37·14
H. 10 (Type 1 × Type 12) .	43·00	42·20	41·49	45·50	43·05

Gram. A preliminary varietal trial with two of the new types (Type 51 and Type 58), in comparison with the old established Type 17, showed a decisive superiority in yielding power for Type 58 over Type 17 but Type 51 was not significantly superior to Type 17.

Hemp. The Fibre Expert to the Government of Bengal, who grew the new Pusa *Hibiscus* (*H. sabdariffa* var. *altissima*) at Dacca, reported the high yield of 27 maunds per acre on a soil which was not particularly fertile. The fibre though spinnable is considered more suitable for rope making. When tested for its suitability as a cordage fibre, the rope stood a strain of 12 cwt. as against the official standard of $15\frac{3}{4}$ cwt. for a manila rope of the same dimensions.

Many other crops are also under investigation, for full details of which and of the numerous points of general interest connected with the work, reference should be made to the Report of the Botanical Section.

Sugarcane. Breeding work on canes which, for climatic reasons, is done at Coimbatore (Madras), is now being supplemented on the sub-station at Karnal (Punjab), financed by the Imperial Council of Agricultural Research, where seeds imported from Coimbatore have been found to germinate successfully. The improved types of thin or sub-tropical cane developed at Coimbatore have replaced the local types on almost a third of the total acreage, and their high tonnage and greater sugar content have led to the establishment of a number of new white sugar factories in the sub-tropical cane belt, fifteen of which are expected to start working during the 1932-33 season. Certain of these sub-tropical canes are now spreading in typically tropical parts of Madras where, for example, Co. 213 is being successfully grown at Anakapalle with restricted irrigation and without the costly operation of wrapping and propping so necessary with thick canes which are liable to lodge during cyclones. Among the recent batches of seedlings distributed, Co. 299, Co. 301, Co. 312 and Co. 313 are the most promising. In periodical analyses of juice of seedlings under distribution, Co. 270 was found to be one of the earliest to ripen, giving 17 per cent. sucrose in October, and it maintained its sucrose content practically at this level until January.

The work on thick or tropical canes, which was started more recently, has reached the stage permitting distribution of the first batch of 16 seedlings (Co. 400—Co. 415) for trial at provincial stations. With a view to increasing the range of possible crosses attempts are being made to control the time of flowering by " topping ", by etiolation and by subjecting the plants to subnormal day-length. Fairly satisfactory results were obtained with " topping ".

Sugarcane-sorghum hybrids. The work on these interesting hybrids, which are intended to provide a sugar-giving plant with a shorter growing period than sugarcane, was actively carried on during the year. The more promising of them were planted at different times and under different conditions and analysed at intervals of a fortnight during the ripening period for cane at Coimbatore. Co. 352 appears to be one of the most promising under Coimbatore conditions. It not only ripens within six to seven months, but also maintains its juice without appreciable deterioration for three succeeding months. At Anakapalle in Madras, some of these hybrids gave over 17 per cent. sucrose in juice at $6\frac{1}{2}$ months from sowing, and fair quality *gur* (raw sugar) is reported to have been obtained. They have also been sent to nearly a dozen stations in sub-tropical India for extensive testing. Up to the present only P. O. J. 2725 sugarcane and *Sorghum Durra* have been employed as parents, and the large number of deaths among the resultant hybrids in the seedling stage were referred to in last year's report. With a view to introducing greater vigour and hardiness, a collection of forty types of sorghum has been made from various parts of the world, and from among them four have been selected for use as parents in future hybridizations after a study of their shoot and root systems.

Testing the yields of new varieties. The application of statistical mathematics to agricultural experiments has been one of the most important advances in field trials in recent years. The testing of varieties to discover the highest yielding type has been carried out in the Botanical Section for some years past, and accurate field trials now constitute an important part of the work of several Sections of the Institute. During the past year the whole practice of field experimentation in the Agricultural Section has been modernised, and this line of work will develop still more in the future with the appointment of the special staff for statistical work.

The results of manurial and varietal trials with sugarcane are given in pages 27—38, and show that Co. 210 is definitely superior in yielding power to Co. 213, while Co. 285 is slightly better than Co. 205. In the case of gram one of the new types (Type 58) has beaten in yielding power the standard Type 17 and in barley Type 21 has maintained its superiority. Trials with oats, however, have reversed the decision as to their relative yielding powers indicated in previous years. This is attributed to the exceptionally dry soil conditions during the season under review and is a warning as to the necessity of repeating trials for several seasons in order to appreciate the variations in yielding power shown by a type under different climatic conditions.

At Pusa, an independent area of land measuring 150 acres is mainly devoted to sugarcane experiments. The testing of new Coimbatore canes for yield and other characteristics, mill trials with selected varieties, the value of green manure with cane and general problems of cane cultivation form the basis of the work. In tonnage experiments with Coimbatore canes, the results were significantly in favour of Co. 210 as against Co. 213, Co. 285 as against Co. 205, and Co. 299 as against Co. 214. Co. 299, which is now in its fourth year of testing, shows possibilities of supplying the need for an early cane with the sucrose content of Co. 214 but of higher yielding capacity.

Plant Diseases

Experiments to determine the natural spread of mosaic disease of sugarcane and the effect of mosaic on the yield and juice of sugarcane have been in progress for the last few years in the Mycological Section, and information of great value has been accumulated which should give a good start to the scheme for a series of investigations on the virus diseases of sugarcane initiated in June 1932 with funds provided by the Imperial Council of Agricultural Research. The year's results indicate a loss, through mosaic, of about 15 per cent. of cane to the grower and of 4 per cent. of sucrose to the manufacturer. These losses are greater than those noticed in the previous year, but the experiment will have to be carried on for some time more before it can be determined whether they come within the range of annual oscillations or whether in the process of vegetative reproduction the effect of the virus disease in successive generations is cumulative.

The study of the three fungi, *viz.*, *Phytophthora* sp., *Rhizoctonia solani* and *Sclerotium rolfsii*, which cause considerable damage to *Piper betel* was continued. Spraying with Bordeaux mixture has given satisfactory results in checking the disease caused by *Phytophthora*, while in the case of *Rhizoctonia* the use of a soil disinfectant combined with sanitary upkeep of betel-vine *borojes* is indicated to be the remedy. Applied to the soil in a concentration of 0·07 per cent., Kerol kills the fungus wherever it comes in contact with it but not the mycelium inside the infected stems which have not thoroughly decayed. The reaction of *Sclerotium rolfsii* to a soil disinfectant is also being examined.

An experiment was carried out to ascertain the effect of treating the seed of various barley varieties before sowing on the incidence of *Helminthosporium sativum* and *H. teres* which destroy the leaf surface. Of the two disinfectants used, *viz.*, formalin (seeds kept soaked for 20 minutes in a 1:320 solution and then under formalin vapour for 30 minutes) and uspulun (seeds treated with 0·25 per cent. solution for one hour), the latter appeared to be more effective. Of the 24 Pusa types of barley under experiment, Types 2 and 3 appear to be more responsive to fungicide treatment, whether formalin or uspulun is used. The resisting power of certain Pusa barleys to *H. sativum* was also tested on the lines indicated in last year's report, but the climatic conditions did not allow conclusive results to be obtained. Similarly the treatment of gram seed with 0·5 per cent. formalin for 30 minutes failed to reveal its effect on the development of the leaf blight fungus *Mystrosporium* sp., because the practically total absence of winter rains itself resulted in the suppression of the disease.

Observations made in two consecutive years have shown the incidence of the wilt disease of chillies to be greater in plots manured with ammonium sulphate and superphosphate and even more in parts of low-lying plots liable to be flooded during the rains. A leaf spot of chillies in the seedling stage causing ultimate rotting of leaves and the death of seedlings was found to have been due to bacteria entering through the stomata, and was controlled by spraying the seed-beds with a one per cent. copper sulphate solution. The sprayed seedlings grew well and gave a normal yield.

Type WR, now known as Type 80, continues to maintain its reputation for resistance to the wilt disease of *Cajanus indicus*. The hope expressed in last year's report of securing a type of pigeon-pea immune from wilt like Type 80 but, unlike it, having the more agriculturally desirable upright or poplar habit, is likely to be realized in Type 51 which is also a high yielder. In the cross between Type 80 (wilt-resistant) and Type 5 (susceptible) pure breeding resistant hybrids have been obtained which possess the poplar habit of the susceptible parent.

Among other diseases under investigation may be mentioned those of cereals and sugarcane caused by species of *Helminthosporium* and *Alternaria*, the stem-rot of *Hibiscus sabdariffa* due to

Sclerotinia sp., and the *Sclerotium* disease of rice which, by inducing excessive tillering and sterility in grain and in certain cases rotting of the stems, causes a loss of both straw and grain.

Insect Attacks

As in previous year, intensive study was made of the early stages of cane borers, specially *Diatraea venosata* Wlk., *D. auricilia* Ddgn. and *Argyria stricticraspis* Hmpsn. How common these borers and termites are on the sugarcane crop will be apparent from the following figures:—

Variety of sugarcane	Number of canes examined (nearly 11 months' growth)	Percentage of canes bored	Percentage of canes attacked by termites
Co. 205	500	51·2	14·0
Co. 213	517	41·3	34·0
Co. 214	507	71·9	14·3
Co. 281	568	37·3	42·6
Co. 303	517	41·0	23·7

Among the other cane pests under observation are *Pyrilla* spp., *Aphis sacchari* Zehnt., *Trionymus sacchari* Ckll. and *Aleurolobus barodensis* Mask.

Pseudococcus corymbatus Green. was present in abnormal numbers on *Hibiscus sabdariffa*, but the affected plants which presented a grey-coppery tinge were treated successfully by spraying with rosin compound.

The investigation of the range of food-plants of various insects resulted in *Rhyncholaba acteus* Cram. being found for the first time feeding on leaves of grape-vine and *Prodenia litura* Fb. on leaves and branches of a medicinal plant known locally as *brahmi*.

The life-histories of about a hundred insects were studied partly or fully, of which certain Syrphid flies, whose larvæ feed on aphides, and *Hæmatopota roralis* Fb., a widely occurring blood-sucking fly of cattle which also occasionally bites man, deserve special mention. Definite proof was obtained during the year that in Pusa the vesicular dermatitis, popularly known as "spider-lick", is caused by a Staphylinid beetle *Pæderus fuscipes* Curt. These beetles are gregarious and are found hiding under spreading plants in damp soil close to rivers and water channels. Dusting with calcium cyanide was found effective in killing them.

The Spread of Improved Varieties of Crops

The spread of improved seeds is mainly carried out by Local Departments of Agriculture who obtain yearly relatively small quantities of seed from Pusa and multiply this for distribution to ryots. During 1931-32, the Botanical Section with its new sub-station at Karnal and the Agricultural Section at Pusa distributed to Provincial Departments of Agriculture and to private growers the following quantities of seed of improved varieties:—51,946 lb. of wheat, 7,869 lb. of barley, 18,074 lb. of oats, 3,720 lb. of gram, 3,071 lb. of pigeon-pea, 1,128 lb. of linseed, 21 lb. of tobacco, 159,601 lb. of sugarcane setts and 2,902 lb. of maize and miscellaneous.

Cattle Breeding and Dairying

Pusa. The pure Sahiwal herd has been established at Pusa for upwards of 28 years; consistent selective breeding governed by performance at the pail has since 1914 improved the milk productive capacity of the breed from 7 lb. to 16 lb. per cow per day. Not only has the entire herd been regraded during the year, according to type conformation and milk production, into four distinct groups, each headed by a bull whose milk pedigree is known for three generations, but a complete reversal of the existing methods of feeding and handling, which were more suitable for cattle with European blood, has been started. All cows are worked on before calving and maintenance rations have been reduced by one-third. The production ration is now fixed at 1 lb. of concentrates to 3 lb. of milk instead of 1 to 2 which was the previous scale, and all cows are now ' taught ' to milk. The increased yield per cow per day of all cows in the experiment averages 7·4 lb., while the fat percentage has remained constant. One cow, whose best previous lactation was 4,014 lb. in 305 days, has given 4,000 lb. in 128 days under the new treatment, while another, which had never given over 2,000 lb. up to her fourth lactation and was written off as a bad milker, has now given over 2,000 lb. in 80 days and is milking steadily.

Karnal. Breeding of two Indian breeds of cattle, *viz.*, Hariana and Thar Parkar, on dual purpose lines for draught and milk is being continued. For financial reasons, it was decided to restrict the cattle herd to 400 head, and to disperse the herd of Murra buffaloes and the flock of Bikaner sheep.

Bangalore. Work on the economic rearing of calves and hand feeding in the case of Indian breeds is being continued. Experimental work for ascertaining the efficiency of pasteurization by different kinds of machines, also on the problem of treating purchased cream for improved flavour and keeping quality of butter is in progress. It has been decided to abandon all experiments in cross-breeding with European cattle to establish a cross-bred herd and to concentrate attention on producing high yielding strains of indigenous breeds.

Wellington. It has been decided to stop all experimental breeding towards the acclimatization of Ayrshire cattle and the establishment of a cross-bred herd, and the farm is to be maintained in future solely as a depôt for the supply of milk, cows in milk being supplied from Bangalore as required and returned when dry.

Anand. Problems of transporting milk over long distances and the most suitable method of treating milk before despatch for distant markets were tried during the year. Though the Creamery has been closed temporarily for financial reasons, it is hoped to resume work with the help of funds provided by the Imperial Council of Agricultural Research.

Animal Nutrition

A further year's work by the Physiological Chemist has confirmed the results previously obtained that the amount of silage fed to milch cattle could be materially reduced without causing a loss in milk yield. In this experiment there was practically no variation either in milk yield or in the fat-content of milk between two groups of cows, one of which consumed 29·2 lb. of fresh silage per head per day and the other received only 17·2 lb. but made up the deficiency by eating more *ragi* (*Eleusine coracana*) straw. As silage is comparatively more costly to make and feed than *ragi* straw, the practical significance of this investigation to dairymen maintaining a large herd can well be imagined. This experiment is being followed up by another on similar lines in which the influence of high and low protein feeding will be determined.

Various Indian coarse fodders are being tested for digestibility. The best results have been obtained with a scented grass, which, however, suffers from the drawback that it is not generally relished in the green state and even when converted into hay is not eaten without hesitation. These experiments have also shown that the digestibility of several ingredients in a fodder decreases as maturity advances.

The effect of supplementing a fodder ration with a mineral is being tested both with growing animals and adult bullocks. In the latter case the fodders used are *ragi* straw and hay, and the mineral is calcium phosphate which at one stage was also supplemented by green food. Determinations of mineral balance have indicated that *ragi* straw is well provided with lime and the phosphoric acid content is on the border line of sufficiency. On the other hand, the hay used appeared to be definitely deficient in phosphoric acid. The influence of phosphate on the assimilation of lime was apparent in both cases.

The study of silage making from *juar* (sorghum) concluded during the year has shown that the prime stage produces the best silage with the least loss, that it is more profitable to ensile the straw rather than to feed it in the raw state, and that the immature plant is quite unsuitable for ensilage.

In addition, various physiological studies are in hand, to which reference should be made in the report of the Physiological Chemist.

Berseem, which is attracting an increasing amount of attention all over India as a leguminous fodder crop, is being grown at Pusa on a large scale. As sometimes more green stuff is produced than could be actually fed, experiments have been undertaken to arrive at the best method of preserving it in silo pits. These indicate that if green berseem and green oats are mixed in layers in the proportion of 2 : 1, there is practically no wastage and the silage is eaten eagerly by all cattle. Further work will be directed towards the use of a smaller ratio of oats, and the question as to the berseem cutting most suitable for silage will be investigated.

II. GENERAL ADMINISTRATION

Charge. On the resignation of Dr. B. A. Keen, Dr. W. McRae was appointed Director from the 15th November, 1931, until the 12th June, 1932, when he was transferred to the post of Agricultural Expert to the Imperial Council of Agricultural Research and Dr. F. J. F. Shaw took over the post of Director.

The post of Joint Director was held by Dr. McRae up to the 14th November, 1931; by Dr. Shaw, from the 15th November, 1931, to the 12th June, 1932; and by Mr. Wynne Sayer, from the 29th June, 1932.

Staff. Owing to absences on leave, etc., the following temporary changes in the charge of the various Sections were made:—

Botanical Section. Khan Sahib Abdur Rahman Khan up to the 18th October, 1931, *vice* Dr. Shaw on leave.

Chemical Section. Dr. Keen up to the 14th November, 1931; Dr. J. Sen from the 15th November, 1931, to the 31st March, 1932; and Mr. J. N. Mukerji from the 1st April, 1932.

Bacteriological Section. Mr. N. V. Joshi up to the 11th November, 1931, and again from the 1st April, 1932, *vice* Mr. J. H. Walton on leave.

Mycological Section. Dr. M. Mitra from the 13th June, 1932, *vice* Dr. McRae on other duty.

Entomological Section. Mr. P. V. Isaac from the 6th April, 1932, *vice* Mr. T. Bainbrigge Fletcher on leave preparatory to retirement.

Agricultural Section. Mr. Arjun Singh up to the 25th November, 1931, *vice* Mr. Wynne Sayer (Officiating Imperial Agriculturist) on leave.

Dairy Section. Mr. Z. R. Kothavala from the 26th September, 1931, *vice* Mr. W. Smith on leave preparatory to retirement. Mr. Kothavala has been appointed Imperial Dairy Expert substantively with effect from the 1st June, 1932.

Animal Nutrition Section. Mr. A. V. Iyer from the 4th April, 1932, *vice* Mr. F. J. Warth on leave.

Sugarcane Station. Mr. N. L. Dutt from the 14th April to the 28th May, 1932, *vice* Rao Bahadur T. S. Venkatraman on leave.

Retrenchment. In common with other departments of the Government of India, the Imperial Institutes of Agricultural Research and Animal Husbandry had to undergo heavy retrenchment, and the sanctioned budget for 1932-33 represents a reduction of Rs. 4,57,400 from that for the year under report. Of this, Rs. 52,000 is accounted for by the 10 per cent. emergency cut in pay and the balance of Rs. 4,05,400 by retrenchment. Such a heavy reduction in the budget involved the closing down of the Creamery at Anand and the Central Bureau of Animal Husbandry and Dairying at Bangalore, the curtailment of the activities of the dairies at Bangalore and Wellington and the cattle-breeding farm at Karnal by reduction of herds and home cultivation, and the drastic pruning down of the various Sections at Pusa. Altogether 7 class I appointments, one class II appointment and 27 non-gazetted posts on the permanent establishments, and several temporary posts were abolished. The permanent posts abolished were distributed as follows:—

	Class I posts	Class II posts	Subordinate staff		Inferior establishment
			Non-ministerial	Ministerial	
Director's office	..	..	..	6	..
Central Bureau of Animal Husbandry and Dairying.	..	..	..	2	..
Imperial Dairy Expert	1	..	..	..	1
Physiological Chemist	..	..	2	..	1
Chemical Section	2	..	..	..	..
Entomological Section	..	..	2	..	..
Mycological Section	1	..	1	..	..
Bacteriological Section	1	..	..	..	1
Agricultural Section	2	..	2	1	6
Karnal Farm	..	..	..	1	..
Wellington Farm	..	1	..	1	..
Total	7	1	7	11	9

The post of the Director of the Institute was throughout the year combined with that of a Head of Section.

Extensions. In spite of the extreme necessity for economy and the limitation of the Budget of the Institute and its out-stations to 10½ lakhs of rupees, the development of the institute as a centre

for fundamental research and post-graduate training of the highest possible standard is being steadily kept in view, and it is proposed to start shortly a sub-section of statistics with a staff of one class II officer and two computors. An additional post of class II Assistant has been sanctioned to strengthen the Entomological Section and a gazetted post of Assistant in the Bacteriological Section has been converted into a post of class II Assistant as a first step towards the reorganization of the Section into one of Soil Microbiology and Bio-chemistry. The scheme for investigations on the diseases of sugarcane, referred to in last year's report, has now been sanctioned by the Imperial Council of Agricultural Research for a period of three years in the first instance, and work has been begun with effect from the 1st June, 1932. The staff sanctioned consists of two gazetted officers, a research assistant and a fieldman.

Training. The position which the Pusa Institute occupies in relation to the Provincial Agricultural Colleges is that of a higher teaching institution, and post-graduate courses of the highest possible standard to qualify for the best appointments in the special branches of agricultural science in India were introduced with effect from November 1923. The position as regards the qualifications for admission to these courses was reviewed during the year under report, and, on the advice of the Imperial Council of Agricultural Research, it has been decided that (1) distinguished graduates who have obtained the highest degree in science, short of a doctor's degree, awarded by their University or an honours degree in science of a high standard or its equivalent, graduates of agricultural colleges who have passed in the first class or have otherwise attained a high position in the college gradation list, and selected officers of Agricultural Departments provided they are fully qualified to take advantage of the courses and are recommended by the Government of the province in which they may be serving, will in future be eligible for admission to these courses, and (2) that in each province there will be a selection committee on which due representation is given to universities, and that the recommendations of such selection committees will go before a selection committee at Pusa which will have the final voice in the selection of students.

During the year under report, five post-graduate students completed their two years' course at Pusa, three in Botany and one each in Mycology and Entomology. One Assistant from the United Provinces Department of Agriculture and another from the Jaipur State completed the special one-year course in farm organization, farm management and general farm engineering. There were 40 applicants for the session beginning on the 2nd November, 1931; twelve were selected for interview, of whom two were admitted in Botany but one left the course after 3 months' training on obtaining an appointment. Two students joined the Agricultural Section for a special one-year course, but one left without completing the course for domestic reasons.

The fifteen-month post-graduate course in animal husbandry, animal nutrition and dairying was completed by two students in

April 1932. Due to the uncertainty prevailing at the time regarding the future of the Bangalore Institute, no fresh admissions were made to this course in January 1932 as in the past.

Out of 24 students admitted to the 2-year Indian Dairy Diploma course in October 1929, 20 passed in the final examination held at Bangalore in December 1931, one of them with Honours. A new class with 20 students was opened in October 1931.

A number of students and post-graduate workers were also admitted for periods of work, or training, in various Sections of the Institute.

Library. The number of publications received in exchange was 3,468, while 696 were purchased. Of the 3,682 books, etc., issued on loan, 361 were to scientific workers in the provinces and universities. The question of providing adequate storage space for the books in the library which now number over 60,000, has become very acute, and steps are being taken to fit up two additional rooms for library purposes.

Buildings. Except that the construction of one class II service officer's quarter begun in the previous year was completed, no funds were available for any original work.

Hospital. There were 394 in-patients and 5,514 out-patients in 1931, and 1,408 operations were performed. The health of the residents of the Estate was, on the whole, satisfactory.

III. ACCOUNTS

The total expenditure for the Institute and its out-stations during the financial year ending the 31st March, 1932, amounted to Rs. 11,89,001 as against Rs. 15,50,062 for the previous year.

Name of establishment	Expenditure
General expenditure of the Institute, including the office of the Director, Power and Gas Plants, the Medical and Estate Establishments	2,37,521
Agricultural Section	1,22,833
Botanical Section	42,532
Chemical Section	60,832
Mycological Section	43,854
Entomological Section	74,048
Bacteriological Section	46,166
Sugar Bureau	2,686
Imperial Dairy Expert	39,807
Bangalore Dairy	1,36,057
Wellington Dairy	89,107
Karnal Cattle Breeding Farm	1,07,148
Anand Creamery	64,381
Physiological Chemist, Bangalore	51,028
Sugarcane Station, Coimbatore	71,001
	11,89,001

In addition, a sum of Rs. 49,190 was provided by Government for buildings for the Botanical Sub-station, Karnal. The cost of the Botanical and Sugarcane Sub-stations at Karnal amounting to Rs. 20,231 and Rs. 11,655, respectively, was met from the funds of the Imperial Council of Agricultural Research.*

The receipts of the Institute and its out-stations amounted to Rs. 3,71,470* as shown below:—

	Sale of dairy produce and live-stock	Sale of farm produce	Fees from students	Miscellaneous receipts	Total
Pusa Institute . .	21,184	13,517	2,625	11,330	48,656
Bangalore Dairy . .	1,15,148	704	2,990	8,234	1,27,076
Wellington Dairy . .	79,205	201	15	3,680	83,101
Karnal Farm . . .	34,682	21,475	..	3,956	60,113
Anand Creamery . .	43,767	..	72	8,685	52,524
Total .	..	..	..	..	3,71,470

* Provisional figure.

REPORT OF THE IMPERIAL AGRICULTURIST

[Wynne Sayer, B.A., Dip. Agri. (Cantab.)]

I. CHARGE

Mr. Wynne Sayer, Officiating Imperial Agriculturist, resumed charge on return from leave on the 26th November, 1931. Mr. Arjan Singh Maan, Assistant to the Imperial Agriculturist, remained in charge in his absence in addition to his own duties.

Mr. Aga Mohamed Mustafa joined the Section as Agronomist on the 26th September, 1931, and was transferred to Baluchistan as Agricultural Officer with effect from the 13th March, 1932.

II. ADVICE

Advice was given as usual to a large number of enquirers on various agricultural matters. One hundred and forty-five visitors from all parts of India were shown round the activities of the Section.

III. POST-GRADUATE TRAINING

Two post-graduate students from the United Provinces completed their course in general agriculture in October 1931. Two new students joined—one in November 1931 and the other in February 1932. The latter had to abandon the course for domestic reasons in March 1932. The two post-graduate students of the Animal Husbandry and Dairying Course, who joined on the 8th February, 1932, finished their training on the 19th April, 1932. A special course of lectures on cane growing was given, and was attended by the Botanical Section students also.

Mr. K. L. Khanna, a student in this Section who finished his special sugarcane course in 1930, was appointed Sugarcane Specialist to the Government of Bihar and Orissa in March 1932.

IV. SEED SUPPLY

Although prices of all agricultural produce were at a low level throughout the year, the demand for seed of improved crops was greater than ever. It proved impossible to supply full indents of pulse seeds as the crop was flooded out in July, so small samples were sent to all applicants with advice on growing their own seed.

The following seeds were distributed:—

	Lb.
Maize No. 1	217
,, ,, 2	141
,, ,, 3	1,407
TOTAL	1,765
Pigeon-pea Type No. 16	216
,, ,, 82	82
,, ,, 69	41
TOTAL	339
Pulse Soybean	609
,, Meth	124
,, Cowpeas	25
,, Peas	37
,, Velvet bean	43
TOTAL	838
Sann-hemp	45
Wheat Pusa 4	5,307
,, ,, 111	2,472
,, ,, 12	3,324
,, ,, 52	6,283
TOTAL	17,386
Barley T. 21	7,001
Oats B. S. I	15,212
,, B. S. II	164
Gram (Pusa Farm Variety No. 15)	20
Sugarcane Co. 285	38,340
,, Co. 210	44,132
,, Co. 213	54,192
,, Co. 214	10,553
,, Miscellaneous varieties	12,384
TOTAL	159,601

V. FARM CULTIVATION

Season. The total rainfall during the year from June 1931 to May 1932 amounted to 41·63 inches, as compared with 33·8 inches in the corresponding period of the previous year, the average rainfall being 45 inches. The late rainfall in June amounting to 1·41 inches in small showers was not enough for sowing, and *kharif* sowing could not be finished until the 7th July. On the 9th July, 10·07 inches fell and the entire crop on the lower lands was destroyed by flood. This was followed by continuous rain (27·89 inches in 28 days) which damaged the high land crops and prevented all intercultivation. 2·49 inches of rain on the 16th October delayed *rabi* sowings, and the complete absence of any winter rains reduced the yield of both grain and straw in the *rabi* crops.

The total area under cultivation during the year was some 761 acres divided as follows:—

1. *General cultivation area—424 acres*, including the reclaimed *dhab* (low-lying) area which is used for irrigated experimental work and fodder experiments.

This area is used for large-scale farming and the greater part is laid out for cultivation by power machinery. New designs of motor tractors and power implements were thoroughly tested on this area during the year.

2. *Field experiment area—187 acres.* This is devoted to the testing, on a field scale and under field conditions, the results of researches made in the laboratory by the various scientific experts of the Institute and now constitutes one of the principal activities of the Section. In addition, special manurial, cultural and variety field trials were conducted on the land by the Agricultural Section.

3. *Sugarcane experiment area—150 acres.* This is an independent unit of land known as the "New Area" and is mainly devoted to sugarcane experiments. The soil is of a light type and the conditions approximate to those under which cane is grown in the district. The testing of new Co. canes for yield and other characteristics, mill trials with selected varieties, the value of green manurial experiments with cane and general cane cultivation problems form the basis of the work.

The question of the most economical cane rotation is one of the principal investigations in progress, and the working of the main area is being based on these results.

In order to find out a plot of the most suitable size for sugarcane experiments, two acres of Co. 205 were cut into 1/480 acre plots. Each plot consisted of a single row of 3′ in width and 30′ 3″ in length, a unit capable of being combined into plots of almost any suitable size for experiments. The cutting figures are being worked out.

VI. FIELD EXPERIMENTS

The following experiments were carried out during the year under report:—

(1) The new types of wheat—P. 111, P. 114, P. 115 and P. 163—evolved by the Imperial Economic Botanist were grown for yield and multiplication of seed against standard types P. 4, P. 12 and P. 52 under zemindari conditions. The results are given below:—

Type of wheat	Area	Yield per acre in lb.
P. 4	5·0	766·70
P. 12	5·5	1,866·32
P. 52	5·0	1,705·60
P. 111	18·0	1,230·00
P. 114	1·0	1,594·90
P. 115	9·0	1,268·54
P. 163	4·0	1,334·14
P. 80/5	9·0	1,447·30

(2) *Yield trial of Imperial Economic Botanist's hybrid oats against B. S. I and B. S. II.* The results of the trial are shown in the following table. In a normal year most of the hybrid oats promised to be superior to B. S. I, but this year, when the soil moisture was rather deficient, B. S. I. has proved superior.

Hybrid oat—	Yield per acre in lb.
A	1,110
B	1,074
C	1,061
D	1,145
E	1,346
F	1,516
G	1,316
H	967
I	1,014
J	1,387
K	1,183
B. S. II	1,406
B. S. I	1,926

(3) *Barley yield trial in Jhilli.* Two acres of land in Jhilli field were put under Pusa Type 21 and Cawnpur Type 251 barleys. In the 28 pairs of plots compared, Pusa Type 21 out-yielded the Cawnpur Type 251 by 174·3 lb. A statistically significant difference with odds of 651: 1 in favour of Type 21 was thus obtained (see page 59).

(4) *Trials of wheat Pusa 52 against country wheat* (a local bazaar mixture) were continued in collaboration with the Imperial Agricultural Bacteriologist according to the local practice of rotation:—Fallow-wheat, maize-wheat. The yields of wheat obtained after maize in *kharif* are given below:—

Plot No.	Pusa 52. Yield in lb. per acre	Plot No.	Country wheat. Yield in lb. per acre
2	641·50	3	639·50
5	680·50	4	514·50
6	639·50	7	697·00
9	615·00	8	574·00
10	621·00	11	629·25
13	629·25	12	596·50
14	629·25	15	596·50
17	596·50	16	674·50

The trials will be continued this year.

(5) *Yield trials of linseed hybrids of Imperial Economic Botanist in South Pangarbi field.* The following are the outturns of linseed varieties:—

Variety	Area in acre	Outturn in lb. per plot	Outturn in lb. per acre
Hybrid . 2	0·83	286	344·58
„ . 10	0·83	354	426·51
„ . 11	0·83	284	342 17
„ . 13	0·83	326	392·77
„ . 63	0·83	281	338·55
Type . 12	0·83	522	628·91

(6) *Rahar yield trial* was carried out in the Nepali field for the Imperial Economic Botanist. The experiments are being continued and will be published later.

(7) An experiment designed and laid out by the Imperial Agricultural Bacteriologist was carried out in 16 plots of 0·25 acre each by the Agricultural Section. The object of the experiment was to see if the two chief drawbacks to the use of green manure in the

rotation, viz., (i) the cost of the seed and (ii) the loss of one crop, can be overcome by the use of the sann-hemp leaves as a green manure while the stems are used for extraction of fibre. The financial results of the experiment are given below. The high cost of labour when the above practice is carried out on a large scale appears to be the only, or real, handicap to the improvement.

Financial results of the green manure experiment

	Rs. A. P.		
Treatment 1 . . .	13 12 2	Value of yield . .	Area 0·25 acre
Plots 1, 8, 12, 13 . .	12 13 0	Cost of cultivation	
Maize and wheat . .	0 15 2	*Profit*	
Treatment 2 . . .	13 14 11	Value of yield . .	Area 0·25 acre
Plots 2, 7, 11, 14 . .	9 14 4	Cost of cultivation	
Urid green-manured .	4 0 7	*Profit*	
Treatment 3 . . .	15 4 4	Value of yield . .	Area 0·25 acre
Plots 3, 6, 10, 15 . .	10 2 4	Cost of cultivation	
Sann-hemp green-manured	5 2 0	*Profit*	
Treatment 4 . . .	29 12 4	Value of yield . .	Area 0·25 acre
Plots 4, 5, 9, 16 . .	19 7 8	Cost of cultivation	
Sann-hemp tops ploughed in and fibre cured.	10 4 8	*Profit*	

Profit per acre

	Rs. A. P.		Rs. A. P.
Treatment 1	0 15 2 × 4		= 3 12 8
„ 2	4 0 7 × 4		= 16 2 4
„ 3	5 2 0 × 4		= 20 8 0
„ 4	10 4 8 × 4		= 41 2 8

8) Yield trial experiments were carried out with wheat, oat and barley varieties in North Pangarbi field under the direct supervision of the Agronomist, who is writing up the results for publication separately.

(9) *The permanent manurial and rotation experiments*, the full details of which have been given in the last year's report, were continued. The yields for the year are as follows. The ten principal treatments contained in plots Nos. 1, 3, 5, 6, 7, 8, 9, 10, 11 and 14 in the Punjab Experimental Area have been laid down in a set of randomised blocks with ten repetitions in order to obtain, if possible, some definite data on this subject.

Results of permanent manurial and rotation experiments during the year 1931-32

	Treatment	A SERIES			B SERIES		
		Kharif 1931	Rabi 1931-32	Rabi 1931-32	Kharif 1931	Rabi 1931-32	Rabi 1931-32
		Maize grain per acre in	Barley grain per acre in	Wheat grain per acre in	Maize grain per acre in	*Rahar* grain per acre in	Barley grain per acre in
		lb.	lb.	lb.	lb.	lb.	lb.
	GROUP I						
1	No manure (Check plot No. 1) .	558	513	...	484	612	...
2	Farmyard manure @ 4,000 lb. per acre.	928	655	...	862	632	...
3	Farmyard manure @ 8,000 lb. per acre.	1,141	1,460	...	1,100	797	...
4	Farmyard manure @ 4,000 lb. per acre *plus* rape cake to supply 20 lb. nitrogen per acre at the time of last interculture.	1,511	1,361	...	1,256	550	...
5	Rape cake @ 40 lb. nitrogen per acre, half to be applied just before *kharif* sowing and half to be applied at last interculture.	1,478	1,109	...	1,150	647	...
	GROUP II						
6	Sulphate of ammonia @ 40 lb. nitrogen per acre, half before *kharif* and half before *rabi* sowing, but in the year when *rahar* is sown it is to be applied in one dose in *kharif*.	862	690	...	509	526	...
7	Sulphate of potash @ 50 lb. K_2O per acre, half before *kharif* and half before *rabi* sowing, but in the year when *rahar* crop is sown it is to be applied in one dose in *kharif*.	797	714	...	501	386	...
8	Superphosphate @ 80 lb. P_2O_5 per acre, half before *kharif* and half before *rabi* sowing, but in the year when *rahar* is sown it is to be applied in one dose in *kharif*.	1,183	1,343	...	1,068	723	...

	Treatment	A SERIES			B SERIES		
		Kharif 1931	Rabi 1931-32	Rabi 1931-32	Kharif 1931	Rabi 1931-32	Rabi 1931-32
		Maize grain per acre in	Barley grain per acre in	Wheat grain per acre in	Maize grain per acre in	*Rahar* grain per acre in	Barley grain per acre in
		lb.	lb.	lb.	lb.	lb.	lb.
	GROUP II—*contd.*						
9	Sulphate of potash @ 50 lb. K_2O per acre and superphosphate @ 80 lb. P_2O_5 per acre, half before *kharif* and half before *rabi* sowing, but in the year when *rahar* is sown they are to be applied in one dose in *kharif*.	1,150	1,326	...	895	920	.
10	Sulphate of ammonia @ 40 lb. nitrogen, sulphate of potash @ 50 lb. K_2O and superphosphate @ 80 lb. P_2O_5 per acre, half before *kharif* and half before *rabi* sowing, but in the year when *rahar* is sown they are to be applied in one dose in *kharif*.	1,203	1,376	..	1,363	821	
11	Sulphate of ammonia @ 40 lb. nitrogen and superphosphate @ 80 lb., P_2O_5 per acre, half before *kharif* and half before *rabi* sowing, but in the year when *rahar* is sown they are to be applied in one dose in *kharif*.	723	741	...	821	1,224	..
13	No manure (Check plot No. 2) .	755	400	.	583	411	..
14	Sulphate of ammonia @ 40 lb nitrogen per acre, sulphate of potash @ 50 lb. K_2O per acre, half before *kharif* and half before *rabi* sowing, but in the year when *rahar* is sown they are to be applied in one dose in *kharif*.	1,068	842	..	706	464	.
	GROUP III						
12	Green manure in conjunction with a purely cereal rotation.	G. M.	...	493	G. M.	.	499
15	Effect of green manure and leguminous crop in the rotation.	G. M.	1,207	..	1,125	567	.
16	As for plot No. 15 but with an additional application of superphosphate @ 80 lb. P_2O_5 per acre to be applied with green manure only.	G. M.	2,807		1,396	739	.
17	No leguminous crop and no green manure.	1,203	...	222	1,068	...	308
18	No manure (Check plot No. 3) .	1,289	269	..	903	493	

(10) Four gram varieties of the Imperial Economic Botanist were grown in Punjab field "A" block for seed multiplication. The field was left fallow in the previous *kharif*. Each variety was grown on eight plots of $\frac{1}{4}$ acre each. The average yield of each variety is given below:—

Gram variety	Average outturn in lb. per acre
T. 28	1,017·75
T. 17	1,068·50
T. 25	1,234·00
T. 58	1,107·50

(11) The chilli experiment of the Imperial Economic Botanist in Jhilli field was a failure on account of diseased seedlings. Hibiscus which was grown for seed multiplication for the Imperial Economic Botanist produced a very good crop in the Middle Pangarbi field.

(12) The following crops were grown in small plots for the study of insect pests by the Imperial Entomologist:—

Kharif.—Turmeric, ginger, maize, soybean, *meth* (*P. aconitifolius*), *guar* (*C. psoraliodes*), *Sesamum indicum*, *mung* (*P. mungo*), *urid* (*P. radiatus*), sann-hemp, castor, *bajra* (*P. typhoideum*), *juar* (*S. vulgare*), roselle, sweet potato.

Rabi.—Chilli, indigo, safflower, sunflower, lentils, linseed, barley, wheat, *methi* (fenugreek), *dhaniya* (*coriander*), potato, tobacco, peas, gram.

(13) *The bullock plough experiment* was continued in the North Pangarbi field with six different types of light bullock ploughs. A plot of $\frac{1}{2}$ acre has been allotted to each plough and the condition of the land and the ploughs will be estimated each year.

Silage Investigations

Berseem was grown in the *dhab* over an area of 116·65 acres under irrigation as usual. The crop was exceptionally good and produced more green stuff than could be actually fed. This crop is attracting an increasing amount of attention all over India and a further summary of results is being prepared for general circulation. The past two years' experiments had shown on a small scale that green berseem could be made into silage with little waste, but the product heated and was not of good colour and appeared prone to mass up through possible lack of drainage in the bulk. A large silo of a capacity of some 3,000 maunds was filled in the middle of February 1932 with green berseem and green oats in layers in the proportion of 2 to 1. The pit was opened on the 12th May, 1932, and was examined by the Imperial Agricultural Bacteriologist whose report follows. There was practically no wastage, and the silage was eaten greedily by all cattle. Further experiments will be conducted this winter with a smaller ratio of oats and the ques-

tion as to the best berseem cutting to make into silage will be investigated along with the use of bacterial cultures.

The following is the report of the Imperial Agricultural Bacteriologist referred to above:—

"The following observations were made on the silage prepared from oats and berseem mixed in a pit.

"The pit was opened on the 12th May, 1932. Temperature at a depth of 6″—19″ from the top was 46°C. which decreased at further depths being 40°C. at 18″. The colour was excellent where oats and berseem had not mixed into each other thoroughly and the layers were separate. The oats were yellow and berseem was dark green. With exposure to light the colours changed slightly and became darker. The silage had a pleasant sweet smell. The total acidity on dry basis was 7·74 per cent. which is higher than that of the last year's experience. It can be definitely said that silage from the mixture of oats and berseem is decidedly better than that made from berseem alone."

Sugarcane Experiments

(1) *Tonnage Experiment No. 1.* This experiment was continued in the New Area in Block No. 1, Series V, VI and VII. These three series were further divided into two sections: A and B. Sugarcane varieties Co. 210 and Co. 213 were interstripped six times in each section of a series in rows of 4, each plot making 1/10 acre in area. There were thus 36 replications of each variety. The first and fourth rows, second and third rows were harvested and weighed separately. The result is highly significant in favour of Co. 210 which gives 3,785·12 lb. per acre over and above Co. 213 on the lighter types of land, an increase of Rs. 15 per acre at present cane rates.

Mean difference in favour of Co. 210 . .	3,785·12 lb.
Standard error	904·214
Critical difference for P=·01	2,463·983

The result is significant at the 1 per cent. level.

(2) *Tonnage Experiment No. II.* This experiment was continued at the New Area to decide finally upon the superiority of Co. 285 over Co. 205. The two varieties were planted on the interstrip method and each was replicated 22 times. The data obtained was subjected to statistical analysis as given below. The result is significant in favour of Co. 285.

Mean difference in favour of Co. 285 . . .	72·06 lb.
Standard error	29·173
Critical difference for P=·01	83·4887
Critical difference for P=·05	60·6798

The result is significant at the 5 per cent. level.

Co. 285 was also subjected to a mill trial at the end of January 1932. The following is the report of the mill trial results:—

Hand mill juice

Date	1st February 1932			19th December 1929	30th December 1931
Variety	Co. 210	Co. 213	Co. 285	Co. 205	Co. 214
Brix . .	20·08	20·14	19·57	17·84	20·38
Pol. . . .	17·51	17·30	16·63	14·31	17·66
Purity . .	87·20	85·89	84·97	80·20	86·65
Fibre . .	16·70	16·31	20·66	22·50	19·00
Sugar per cent. on cane.	13·52	13·28	11·63	9·74	13·22

Mill juice

Variety	Average 6th December 1931 to 31st January 1932	1st February 1932	Average 16th November 1931 to 5th December 1931
	Co. 210 and Co. 213 mixed	Co. 285	Co. 214
Mixed juice			
Brix	16·03	18·23	16·84
Pol.	12·98	14·94	13·06
Purity (Lead) . . .	80·97	81·95	77·55
Sugar (sugar per cent. on juice)	13·06	15·04	13·22
Per cent. cane (per cent. juice on cane).	83·15	66·10	79·51
Comp. value (sugar per cent. on cane).	10·86	9·94	10·53

This cane has now been distributed to growers.

(3) *Tonnage Experiment No. III.* The chief drawback to the Co. 214 early ripening type of cane is its low tonnage, and in consequence every endeavour has been made to find a cane equally early with higher tonnage. An experiment was carried out in Harpur Jhilli field where Co. 299, which shows promise of becoming an early cane upto the mill standard of Co. 214, was interstripped with Co. 214 in alternate rows for tonnage trials. There were 30 rows of each variety. The result is highly significant as shown below in favour of Co. 299. The experiment will be repeated this year, the canes being cut at the earliest possible date in the mill-season :—

Mean difference in favour of Co. 299 . . .	541·4 lb.
Standard error	34·819
Critical difference for P=·01	95·961

The result is highly significant at the 1 per cent. level.

History of Co. 299. This cane which is now in its fourth year of testing shows a likelihood of becoming an early cane of improved tonnage to Co. 214 while maintaining a sucrose content for early crushing which is very little below Co. 214.

It is an upright cane which tillers well; it displays great resistance to drought and has all the characteristics of an early cane.

Sucrose per cent. and yield of Co. 299 from 1928-29 to 1931-32

Year	Field	Sucrose per cent				Yields in maunds * per acre
		November	December	January	February	
1928-29 .	Brick-field II	12·49 13·31	15·33 16·51	16·53	17·26	296 1st and 3rd week.
1929-30 .	Jhilli . .	14·92	15·83	16·44	17·51	583
1930-31 .	Bhograsan .	15·73 16·95	17·64 18·61	16·13 17·24	17·38 17·56	492
1931-32 .	Harpur Jhilli	13·47	16·19	17·35 17·15	..	597

(* One maund = 82 lb.)

(4) *Tonnage Experiment No. IV.* This mosaic tonnage experiment was carried out in the Bhograsan field in collaboration with the Imperial Mycologist. After harvesting the sugarcane crop of 1930-31 in the month of January 1931, the cane stubble was ploughed up and the same land was again utilized for this experiment. The plot was heavily manured with oil-cake and Co. 213 was planted in February 1931. Planting material, both healthy and mosaic, was taken from the previous crop of the mosaic experiment in the Gonrhi field. Each plot was 5 rows × 60 yards, *viz.*, 15 feet × 180 feet. The results have been dealt with by the Imperial Mycologist.

Sugarcane manurial experiments

(*a*) Manurial experiments were carried out on Co. 210 in collaboration with the Imperial Agricultural Bacteriologist in Harpur Jhilli. Sulphate of ammonia was tested against nitrate of soda and niciphos in two different sets. Eighteen strips of four rows each were set apart for these experiments. The area of each strip was 1/9 of an acre. There were four replications of sulphate of ammonia against niciphos and five replications of sulphate of ammonia against nitrate of soda. Each manure was top-dressed at 2 cwt. per acre in addition to the basal dressing of standard manure. Niciphos was of 22/18 grade—18·12 per cent. N and 18 per cent. P_2O_5; nitrate of soda was of 15/15½ per cent. N grade; and sulphate of ammonia was of 20·6 per cent. N grade. The experiment was on a price basis, the cost of 2 cwt. niciphos being Rs. 22, 2 cwt. $NaNo_3$ Rs. 18-8-8 and 2 cwt. Am_2SO_4 Rs. 17-2-4.

The detailed statement of yield from each plot is given below:—

Plot No.	$NaNo_3$	Yield per acre	Plot No.	Am_2SO_4	Yield per acre
		Mds. Srs. Ch.			Mds. Srs. Ch.
1	..	765 27 0	2	..	761 16 0
3	..	724 2 0	4	..	736 17 0
5	..	730 23 0	6	..	750 6 0
7	..	756 27 0	8	..	773 22 0
9	..	769 38 0	10	..	775 23 0
		3,746 37 0			3,797 3 0
Average yield . .		749 15 6	....		759 16 9

Difference in favour of Am_2SO_4 — 10 maunds.

Plot No.	Niciphos	Yield per acre	Plot No.	Am_2SO_4	Yield per acre
		Mds. Srs. Ch.			Mds. Srs. Ch.
1	..	757 32 0	2	..	737 22 0
3	..	779 25 0	4	..	738 0 0
5	..	788 34 0	6	..	789 3 0
7	..	760 2 0	8	..	723 15 0
		3,086 13 0			2,988 0 0
Average yield . .		771 23 4	....		747 0 0

Difference in favour of Niciphos—24 maunds and 23 seers.

The results were not statistically significant.

(*b*) In manurial experiments with sulphate of ammonia and nitrate of soda both top-dressed at the rate of 2 maunds per acre to Co. 210 and Co. 213 the former gave a higher yield in the case of both Co. 210 and Co. 213 but the results are not statistically significant.

Variety Co. 210—

Mean difference in favour of $(NH_4)_2SO_4$ . . . 6·4 mds.
Standard error . . . . . 12·0595
Critical difference for P=·01 . . . . . 34·949
& P=·05 . . . . . 25·445

The difference is insignificant.

Variety Co. 213—

Mean difference in favour of $(NH_4)_2 SO_4$ . . . 19·3 mds.
Standard error . . . . . 17·455
Critical difference for P=·01 . . . . . 50·584
& P=·05 . . . . . 36·830

The result is not significant.

Trashing experiment

One of the chief handicaps to growing early ripening canes on a large scale is the damage done to the seed-cane when standing in the field from November to February after the main crop has been harvested. Up to 70 per cent. of the crop has been known to be destroyed by jackals and pigs owing to the over-ripe condition of

the cane, and this damage has been the cause of much bad germination in the next crop and heavy loss in seed-cane. To obviate this difficulty an experiment was laid down with Co. 281, one of the earliest ripening canes—having from 13·78—16·66 per cent. sucrose in cane in November. This cane was cut on the 26th and 28th December, laid on the ground on a layer of cane leaves and covered by another layer of dry trash. The cane thus treated remained up to the end of February when it was taken out for planting. Sixty-six per cent. of the cane was found perfectly suitable for planting. It was planted in lines against fresh cane and the germination observed. The figures are given below:—

	No. of setts planted	Eye-buds planted	Percentage germination
Trashed setts	318	881	38·8
Fresh setts	292	876	45·4

The germination of the trashed cane was rather slower than that of the fresh, but the difference had disappeared by the break of the monsoon. It is estimated that by this method it will be possible to keep full supplies of early cane seed in good condition without any extra expense to the grower. A description, with photographs, of the whole operation is being published.

Sugarcane variety tests

Out of the list of Coimbatore canes grown in New Area and Harpur Jhili, the year under report saw Co. 720, Co. 298, Co. 305, Co. 308, Co. 315 and B.S. 11 finally discarded as being below standard in all respects. The yields for 1930-31 are given for comparison.

Yield of sugarcane varieties at Harpur Jhilli and New Area for the year 1931-32 along with sucrose percentage and yield of sugarcane crop for 1930-31

Serial No.	Sugarcane variety	Sucrose %			Outturn of H. Jhilli, 1931-32		Outturn of N. Area, 1931-32		Yield of sugarcane crop for 1930-31 in maunds per acre
		November 1931 / 1930	December 1931 / 1930	January 1932 / 1931	Area	Outturn per acre in mds.	Area	Outturn per acre in mds.	
1	Co. 205	10·58 12·29	14·44 13·67	14·04 14·89	0·145	415·51	1·72	439·8	446
2	Co. 210	13·17 14·67	15·64 15·97	15·97 14·97	2·088	701·87	11·25	450·0	404 to 455
3	Co. 213	11·08 14·20	14·70 14·89	15·34 17·11 15·36	0·174 0·116	678·16 500·00	8·60	464·0	749
4	Co. 214	16·00 14·12 16·31	17·34 14·78 16·48	17·74 15·66 17·78	0·522 1·025	321·59 383·80	1·00	369·5	276
5	Co. 270	12·86 12·82	14·48 16·36	15·54 14·56	0·493	467·33	..	..	400
6	Co. 281	13·78 16·66	18·01 18·12	.. 17·69	0·174 0·145	362·06 291·38	1·37	309·0	443

Yield of sugarcane varieties at Harpur Jhilli and New Area for the year 1931-32 along with sucrose percentage and yield of sugarcane crop for 1930-31—concld.

Serial No.	Sugarcane variety	Sucrose %			Outturn of H. Jhilli, 1931-32		Outturn of N. Area, 1931-32		Yield of sugarcane crop for 1930-31 in maunds per acre
		November 1931 / 1930	December 1931 / 1930	January 1932 / 1931	Area	Outturn per acre in mds.	Area	Outturn per acre in mds.	
7	Co. 285	11·88 15·11	15·70 16·54	15·81 16·99	0·203	812·87	1·70	567·0	604
8	Co. 298	11·99 14·91	13·48 16·35	15·52 15·90	0·290	430·51	0·12	274·0	291
9	Co. 299	13·47 16·95	16·19 17·64 18·61	17·15 17·35 17·24	1·025	596·78	0·57	313·0	492
10	Co. 300	16·64 13·05	16·75 14·59	16·95 16·12	..	..	0·25	372·0	321 to 541
11	Co. 301	13·96 14·71	14·22 14·42	14·53 16·17	..	..	1·00	531·0	375 to 662
12	Co. 302	11·33 13·65	14·90 15·02	17·78 15·37	..	..	0·57	411·0	287

13	Co. 303	11·74 13·06	14·08 16·14 15·67	16·15 15·81 16·18	..	..	1·00	520·0	475
14	Co. 304	11·14 13·14	13·34 16·03	15·34 14·86	0·116	717·02	..	..	812
15	Co. 305	11·29 14·91	14·55 15·22	16·18 17·71	0·087	119·25	..	..	217
16	Co. 308	11·12 16·75	13·54 17·24	16·16 15·48	0·203	383·62	..	..	292
17	Co. 312	14·76 11·26	13·34 15·86	16·59 13·26	0·174	586·20	0·55	728·0	572
18	Co. 313	13·23 13·64	16·46 16·61	17·77 18·58 15·97	0·348	537·14	..	..	495
19	Co. 315	11·81 15·91	14·56 15·52	.. 15·73	0·232	311·20	..	..	216
20	Co. 316	12·90 13·59	13·58 15·41	14·65 18·81	0·174	418·10	0·75	420·0	384
21	B. S. 11	11·52 13·09	14·58 15·86	16·39 15·41	1·218	528·16	..	..	636

(2) The varieties in the group Co. 317 to Co. 337 which were multiplied in the nursery were grown under field conditions. Sucrose per cent. and yield per acre are given in the following table. The area under each variety was too small for any close comparisons regarding tonnage, but Co. 320, Co. 321, Co. 323, Co. 324, Co. 325, Co. 328, Co. 329, Co. 330, Co. 334 and Co. 336 have been rejected as being too much of a *barani* type for the tract. Co. 331 is proving a cane of remarkable agricultural habit, but it appears at present to be a late ripener on good land.

Yield of new varieties of sugarcane at New Area during the year 1931-32

Serial No.	Sugarcane variety	Sucrose per cent.			Area	Outturn per acre in mds.
		November 1931	December 1931	January 1932		
1	Co. 317 . .	12·97	15·76	16·94	0·0126	526
2	Co. 318 . .	10·91	13·60	14·11	0·0126	528
3	Co. 319 . .	12·43	14·65	15·06	0·0126	250
4	Co. 320 . .	12·38	15·41	16·90	0·02	426
5	Co. 321 . .	12·07	14·69	16·72	0·02	428
6	Co. 322 . .	13·36	17·20	17·48	0·02	641
7	Co. 323 . .	15·08	17·22	17·95	0·14	364
8	Co. 324 . .	15·63	15·09	16·97	0·14	371
9	Co. 325 . .	11·69	14·84	15·77	0·20	431
10	Co. 326 . .	10·29	13·41	13·09	0·08	575
11	Co. 327 . .	12·11	14·98	15·88	0·16	483
12	Co. 328 . .	11·98	15·21	15·81	0·12	548
13	Co. 329 . .	13·85	15·90	17·28	0·06	280
14	Co. 330 . .	15·07	13·80	16·86	0·02	512
15	Co. 331 . .	13·22	13·27	15·18	0·08	720
16	Co. 332 . .	15·26	15·18	16·33	0·02	416
17	Co. 333 . .	12·75	14·87	15·63	0·02	412
18	Co. 334 . .	13·00	15·77	17·46	0·02	425
19	Co. 335 . .	12·42	14·53	15·25	0·02	500
20	Co. 336 . .	15·49	14·98	17·01	0·02	425
21	Co. 337 . .	15·53	16·95	17·77	0·02	450

(3) The third group consists of the varieties Co. 338 to Co. 357 which were received from the Government Sugarcane Expert in March 1931. They were grown in the nursery and analysed. The sucrose percentage is given below.

Co. 341 and Co. 342 look promising from the agricultural side but appear to ripen late. Co. 351 to Co. 357 are the sorghum hybrids. They were planted in the middle of March but failed to ripen in six months, as is seen from the analysis figures taken in October which are given below:—

Sugarcane varieties grown at New Area Nursery during 1931-32

Serial No.	Sugarcane variety	October 1931		November 1931		December 1931		January 1932	
		Sucrose	Purity	Sucrose	Purity	Sucrose	Purity	Sucrose	Purity
		%	%	%	%	%	%	%	%
1	Co. 338	...	...	14·15	78·86	15·36	76·67	16·62	80·84
2	Co. 339	..	...	12·89	77·71	15·83	83·13	16·76	81·00
3	Co. 340	...	...	8·21	66·35	12·57	74·21	12·91	74·25
4	Co. 341	...	...	10·68	72·09	14·57	78·58	14·87	79·33
5	Co 342	..	...	10·36	71·16	15·08	80·82	16·47	83·57
6	Co. 343	...	...	7·53	63·57	12·47	75·40	13·69	71·15
7	Co. 344	...	...	11·87	75·46	15·16	82·51	16·34	80·83
8	Co. 345	...	...	12·62	76·11	15·64	81·95	17·42	86·07
9	Co. 346	...	...	9·02	64·30	12·58	68·46	14·85	80·53
10	Co. 347	...	...	7·63	61·16	13·81	78·16	15·02	80·56
11	Co. 348	...	...	9·74	66·33	12·05	72·39	16·90	78·45
12	Co. 349	...	...	9·16	76·57	13·72	75·22	15·73	82·03
13	Co. 350	...	...	11·44	71·10	15·11	79·39	13·43	77·56
14	Tuc. 393	...	...	6·74	56·57	12·47	71·80	12·48	72·70
15	Tuc. 472	...	...	5·71	53·39	13·92	77·05	15·88	82·77
	Serghum hybrids								
1	Co. 351	9·33	66·52						
2	Co. 352	9·83	69·72						
3	Co. 353	7·00	60·97						
4	Co. 354	5·87	58·89						
5	Co. 355	6·57	60·19						
6	Co. 356	6 50	58·36						
7	Co. 357	30·2	38·97						

Cost of growing sugarcane

Sugarcane was grown at the New Area without irrigation as is the practice in North Bihar. Detailed cultivation data was maintained.

The following is the cost of cultivation and manuring per acre over an area of 32·24 acres:—

	Rs.
Preparatory charges	11·85
Manuring	48·97
Planting	9·96
Seed	20·21
Interculture	6·25
Total	97·24

Average yield per acre	453 maunds.
Cost per maund	annas 3·43

VII. MACHINERY

Steam Ploughing Set

(1) The steam ploughing set worked during the year for 44 days as against 82·85 days in the previous year. The increasing area of land laid down in small experiments on the farm has rendered the economic use of such a large outfit very problematic. It has, therefore, been decided to bring the set into use in future in cases of emergency only and to carry out all main cultivation operations with crude oil tractors.

The details of working costs, etc., are given in the following statements.

Statement showing output, consumption and cost of working by Steam Tackle for the year 1931-32

(*a*) Output

Year	Working days	Summary of work done										Acreage per hour			
		Ploughing		Disc harrowing		Grubbing		Rolling		Total	Total	Plough-ing	Disc harrow-ing	Grubb-ing	Rolling
		Days	Acres	Days	Acres	Days	Acres	Days	Acres	Days	Acres	Acres	Acres	Acres	Acres
1931-32 . .	44·25	17·15	174	12·55	271 5	8·7	265	5·85	187·5	44·25	898	10·14	21·63	30·45	32·05

(*b*) Consumption

Year	Working days	Coal		Wood		Lubricants	
		Total	Per day	Total	Per day	Total	Per day
		Mds.	Mds.	Mds.	Mds.	Mds.	Mds.
1931-32	44·25	1,685	38-2-12	45	1-0-6	8-23-3	7-9

(*c*) Cost

Year	Working days	Cost						Cost per acre			
		Labour	Coal and Wood	Lubri-cants	Renewals	Total	Per day	Plough-ing	Disc harrowing	Grubbing	Rolling
		Rs.	Rs.	Rs.	Rs.	Rs	Rs.	Rs.	Rs.	Rs.	Rs.
1931-32	44·25	533-9-5	748-7-0	143-3-11	424-11-5	1,849-15-9	41-12-9	4-1-11	1-14-10	1-5-11	1-4-9
							(41·80)	(4·12)	(1·93)	(1·37)	(1·30)

Tractors

(2) Three tractors, Lanz Bulldog (crude oil), McCormick-Deering and Vickers (kerosene) worked throughout the season. A second crude oil tractor (Marshalls) was brought on test towards the end of June, but no data are yet available.

The working costs of the three tractors are given below. The saving in costs per acre of the crude oil outfit continues to be most noticeable in all classes of work.

In taking costs per acre, particular care should be taken to realize that the cost of spare parts has ultimately to be averaged throughout the tractor's working life. Yearly costings as given in the tables here are obliged to be based on the acreage worked in the year the spare parts were purchased. A final statement issued when the tractor is worked out, will give the actual average cost per hour of the tractor's working life.

The output of ploughing was considerably increased by proper tractor ploughs being worked with each tractor, the Lanz taking a 3-furrow Vice-Consul, the McCormick Deering a 4-furrow Little Genius and the Vickers a 5-furrow Vice-Consul. This improved the class of work done and enabled the tractors to be worked at their most efficient capacity. The same cannot yet be said about the other implements. A tractor is not a mechanised bullock, and tractor implements—not horse implements with a tractor hitch—are wanted for efficient working. It is essential that all implements should have a variable spread for working with different types of tractors on varying classes of land—whether this spread is best attained by hinging, lifting, folding or telescoping wing frames has to be worked out and it is useless to attempt to gauge a tractor's real efficiency at minor operations until this has been done. The loss in efficiency is best seen by the fact that a Vickers tractor pulls a 9-ft. drill when it could handle a 24-foot, but implement makers have still to imagine a 24-foot drill. Implement speed is another uncharted sea; if a tractor which pulls a 4-furrow plough at 2 mph. can pull a 3-furrow at 4 mph. on a higher gear, the gain in the day is considerable, but we have no knowledge whether the higher speed is bad for the land or not or whether the tilth produced by multiple operations in one run is better or worse than that produced by separate operations. All these problems call for investigation without delay.

Statement showing output, consumption and cost of cultivation by Tractors during 1931-32

(*a*) Output

Tractor	Working hours	Summary of work done											Acreage per hour				
		Ploughing		Disc harrowing		Grubbing		Drilling		Rolling		Total	Ploughing	Disc harrowing	Grubbing	Drilling	Rolling
		Hours	Acres	Hours	Acres	Hours	Acres	Hours	Acres	Hours	Acres	Acres					
Lanz Bulldog	290·25	114	99	103·75	200	33·5	75	...	...	39	109·5	483·25	0·868	1·928	2·238	...	2·807
Vickers	257·75	152·25	225·15	97·25	230·5	7·25	14	...	..	1	3	472·65	1·478	2·37	1·931	...	3
McCormick Deering	324·75	130·75	138	166	326·85	...	...	20·50	64	7·5	15	543·85	1·055	1·883	..	3·122	2

(*b*) Consumption

Tractor	Working hours	Fuel		Engine and gear oil		Grease		Waste	
		Total gallons	Per hour gallons	Total gallons	Per hour gallons	Total	Per hour	Total	Per hour
						lb.	lb.	lb.	lb.
Lanz Bulldog	290·25	Crude oil— 550·585 K. oil— 11 957	Crude oil— 1·896 K. oil— 0 041	50·5	0·173	51·62	0·177	22·25	0·076
Vickers	257·75	K. oil— 983·608 Petrol— 18	K. oil— 3·816 Petrol— 0·07	51·928	0·201	50	0·193	27	0·104
McCormick Deering	324·75	K. oil— 854·154 Petrol— 25	K. oil— 2·63 Petrol— 0·076	75·933	0·233	63	0·194	37·87	0·116

(*c*) Cost

Tractor	Working hours	Analysis of total cost								
		Wages of mistries and water carriers	Crude oil	Kerosene and petrol	Lubricants	Spare parts	Sundry stores	Repairing staff and misc. wages	Total	Cost per hour
		Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.
Lanz Bulldog	290·25	36 3 0	213 4 6	9 0 8	174 5 1	319 6 3	1 8 0	66 9 3	820 4 9	2 13 3
Vickers	257·75	35 13 8	...	754 6 6	162 1 1	605 7 3	21 5 0	107 15 5	1,687 0 11	6 8 9
McCormic Deering	324·75	47 0 2	...	684 14 1	162 12 8	644 11 0	40 0 7	135 3 3	1,714 10 2	5 4 6

(*d*) Cost per hour

Tractor	Ploughing	Disc harrowing	Grubbing	Drilling	Rolling
	Rs.	Rs.	Rs.	Rs.	Rs.
Lanz Bulldog	3·255	1·466	1·262	...	1·007
Vickers	4·428	2·761	3·389	...	2·181
McCormic Deering	5·003	2·803	...	1·69	2·639

Statement showing output, consumption and cost of belt pulley work by Tractors during 1931-32.

Tractor	Working hours	Crude oil		Kerosene oil		Petrol		Lubricants	
		Total	Per hour	Total	Per hour	Total	Per hour	Total	Per hour
		gallons	gallons	gallons	gallons	gallons	gallons	gallons	gallons
Lanz Bulldog	23	19·999	0·869	0·948	0·041	...	...	2·975	0·129
		Rs. A. P.		Rs. A. P.				Rs. A. P.	
		7 11 11		0 11 2				7 11 10	
Vickers	76·75	...	...	150·580	1·961	10	0·13	19·842	0·258
				Rs. A. P.		Rs. A. P.		Rs. A. P.	
				115 0 7		15 10 0		43 14 5	
McCormick Deering	146	...	...	207·22	1·42	10	0·07	15·43	0·105
				Rs. A. P.		Rs. A. P.		Rs. A. P.	
				157 7 9		15 7 0		29 3 10	

Statement showing output, consumption and cost of belt pulley work by Tractors during 1931-32—contd.

Tractor	Grease		Waste		Spare parts	Sundry stores	Mistries and water carriers	Repairing staff and miscellaneous wages	Total expenses	Expenses per hour
	Total	Per hour	Total	Per hour						
	lb.	lb.	lb.	lb.						
Lanz Bulldog	...	...	2·75	0·119	...	...	...	...	...	...
			Rs. A. P.		Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.
			0 6 9		25 4 9	0 1 3	2 0 3	5 4 3	49 3 3	2 2 3
	lb.	lb.	lb.	lb.						
Vickers	12	0·156	7·75	0·1	...	...	...	...	...	...
	Rs. A. P.		Rs. A. P.							
	4 8 0		1 1 10		180 7 9	6 5 1	9 7 1	32 1 3	408 8 0	5 5 2
	lb.	lb.	lb.	lb.						
McCormick Deering	24	0·177	7·75	0·05	...	...	...	...	...	...
	Rs. A. P.		Rs. A. P.							
	7 3 8		0 14 2		289 13 0	17 15 3	16 0 1	60 12 8	594 13 5	4 1 2

Thresher

(3) Considerable attention has been devoted this year to the question of designing a small thresher to suit all-India requirements.

The small Peasant thresher, brought out in March 1931, was given a full test under Indian conditions and the results are given below. A special type of bullock gear was designed to give a speed of 1,000 rpm. at the drum and allow the bullocks to tread out the *bhusa* while working. Most of the wooden parts of the thresher had to be replaced, and several alterations were made to suit local conditions from time to time.

The thresher was worked for varying periods on the farm from the 30th March to the 26th April 1932, the longest run being over $7\frac{1}{2}$ hours.

The wheats threshed were Pusa 52 and Pusa 163. The weather conditions were variable and the best work was done from the 22nd to 26th April when 68 maunds and 24 seers of P. 52 were threshed in 12 hours and 22 minutes—an average of 5 maunds and 22 seers per hour. The largest quantity produced in an hour was 6 maunds and 16 seers. The whole machine worked well and no trouble was experienced. No grain was broken and the recovery was very thorough.

The machine was subsequently worked under local conditions in the neighbouring village of Bhuskaul, where it gave every satisfaction. It worked for $10\frac{1}{2}$ hours and threshed out 14 maunds 11 seers of grain. The crop was very poor and the grains very small —this accounting for the lower output.

A new type of small thresher, incorporating all the necessary alterations, bringing it down to the Indian price standard, has now been completed with a new type of drum, and this will be given a thorough testing in the next threshing season.

A note on the work done on threshers at Pusa and the general all-India threshing problem, was written up for the Imperial Council of Agricultural Research.

Twelve different types of plough were tested during the season.

VIII. CATTLE BREEDING

The Pusa pedigree Sahiwal herd stood at 201 head on the 30th June 1932. The entire herd kept excellent condition throughout the year and there was no outbreak of any contagious disease among them.

With the discontinuance of the cross-breeding experiments, the main herd of Ayrshire-Sahiwal stock has been dispersed and the few remaining cows are now offered for sale. A study of Table I in the Appendix will show that the difference in milk yield per cow per day between the two herds had at the time of dispersal been

reduced to under 3 lb. per cow, and the selective breeding and grading up of the Sahiwal herd is rapidly bringing them up to the level of the average cross-bred herd as milk producers.

With the dispersal of the cross-bred herd and the termination of the experimental work thereon, it has been possible to devote increased time and attention to the pure breeding side.

The pure bred Sahiwal herd has been established for upwards of 28 years for which period of time breeding records have been maintained, while full milk records are in evidence from 1914 onwards. These records probably constitute the largest collection of evidence regarding the behaviour of any pedigree herd in India. The sifting and close study of these records has now been taken in hand with a view to obtain data on the transmission of milk characters and general breed points throughout this period.

Consistent selective breeding governed by performance at the pail for this period has improved the milk productive capacity of the breed from 7 lb. up to 16 lb. per cow per day as is also shown in Table I in the Appendix, but a considerable degree of lack of uniformity has manifested itself among the best milkers, with the result that it has in the past been impossible to fix a definite type representative of the best milking characteristics of the breed. The entire revision of the old method has now been completed and a definite standard of breed points set up to fix certain definite characters in the herd which are regarded as essential by all judges and breeders. The herd has been linked to milch standards and the tendency towards beef is now being rigorously eliminated.

The question of the transmission of milch characters through the male line is receiving close attention, and endeavours are being made to link up the histories of the 20 bulls which have already been tested through the herd with the breed points of their best milking descendants. The actual points of value in milk transmission are unknown in this breed, and nothing but the careful testing of each bull through his progeny can give us any information outside guess work to justify bringing the bull back into the herd for definite milk improvement. The dulness of bulls of the Sahiwal breed at Pusa later in life has been a great handicap to this investigation in the past, but experiments are now in train to overcome this, and it is hoped by these means to augment the milch transmitting powers of the herd in future.

The entire herd has been regraded according to type conformation and production into four distinct groups, each headed by a bull whose milk pedigree is known for three generations.

Transmission of characters. In one group headed by a bull bred from a strain noted for longevity, regular breeding and high milk production coupled with a distinct tendency on the dam and granddam's side to produce a majority of female calves, a study is being made of the transmission of these factors which are of such essential importance to the breed.

Feeding. In any herd where the study of milk-producing factors is based on performance, feeding problems are of the greatest importance, as it has been made abundantly clear in the last few years that full milk performance can only be expected when all the specific mineral deficiencies in the ration have been eliminated and a proper ration basis for full health established. A beginning was made with this work at the end of the year and the results to date are proving instructive and will probably demonstrate the advisability of extending work on these lines.

Special handling and feeding. It has for some time been increasingly evident that the handling and feeding methods suitable for cross-bred cattle which have been accepted as standard in most farms and dairies in India were not entirely suited to the Sahiwal, and the percentage of well-bred Sahiwals in the Pusa Herd failing to milk up to their breeding was becoming steadily larger. This pointed to reabsorption of milk, and a complete reversal of the existing methods of feeding and handling has, therefore, been started. All cows are worked on before calving—maintenance rations have been reduced to two-thirds. The production ration is now fixed to be 1 lb. of grain mixture to 3 lb. of milk instead of 1 to 2 which was the previous scale and *all cows are now taught to milk.* The increased yield per cow per day of all cows in the experiment averages 7·4 lb., while the fat per cent. of the milk has remained constant. The average body weight at the commencement of the experiment was 783 lb., and at the date of writing 800 lb.

To illustrate the above the graphs (Plate I) of two cows in the experiment are given:—

(1) Ajbi No. 567, whose best lactation was 4,014 lb. in 305 days, has given 4,000 lb. in 128 days under the new treatment.

(2) Algi No. 531 had never given over 2,000 lb. upto her fourth lactation. She has now given over 2,000 lb. in 80 days and is milking steadily. She was formerly written off as a bad milker and only fit to draft.

Calf rearing. The late maturity of the Sahiwal herd being one of the great drawbacks to rapid improvement of milch characters, a system of calf rearing has been started with a view to obtaining the earliest possible maturity; calves are fed on a special grain and milk ration and it is hoped by this means to bring heifers in at 18 months fully developed and enable bulls to start service at two years, thereby shortening their proving period and obtaining a longer use of the bull when brought back.

The following are the chief problems for the study of which the records kept from 1904 are being examined:—

(1) To establish milk;

(2) To improve milk yield;

(3) To fix a type incorporating as far as possible the physical characters of the best milkers;

(4) To definitely grade out all beef type transmitters from the herd;

(5) To fix certain definite characters in the breed which are regarded as essential by all judges and breeders;

(6) To adopt a system of advance registry;

(7) To grade the whole milch herd into classes;

(8) To trace and fix certain characters transmissible and hereditary and link them definitely with certain lines;

(9) To establish definite data for the correction of milk records in order to bring them into line with other herd records;

(10) To discover and record the best method of feeding, milking and handling the breed linked with the question of reabsorption of milk;

(11) To settle the most profitable calving intervals for each lactation;

(12) To work out the possibility of higher feeding with earlier maturity, increasing the earning period of each cow;

(13) To study carefully the effect of all line-breeding already done and its guide to subsequent work;

(14) The effect of in-breeding on the yield, constitution and general condition of the Sahiwal, particularly with relation to fertility;

(15) To investigate any Mendelian ratio which may be evident in transmission and to endeavour to trace any definite line of inheritance of characters under this law

IX. PROGRAMME OF WORK FOR 1932-33

1. Cultivation investigations with special reference to production of tilth and condition of soil associated with speed of implements.

2. Green-manuring investigations with special reference to water requirements in various soils and conditions required by different crops.

3. General treatment of a 600-acre farm with special reference to reduction of costs in cultivation and the rotations suitable to the introduction of machinery.

4. Line-breeding investigations with a pedigree herd of Sahiwal cattle with special reference to the transmission of milch characters.

5. Investigation of the threshing problem in India and the design of a small threshing plant to suit all-India requirements.

6. Experiments with various types of motor tractors and general tractor implements for collection of data and determination of most suitable types of tractors and implements for Indian conditions.

Collaboration with manufacturers with regard to the manufacture and test of new types of implements built to correlate with present tractor design.

7. Investigations on silage problems.

8. Experimental work—

(*a*) The design, lay-out and general technique connected with modern field experiments.

(*b*) Trials of new varieties of crops.

(*c*) Manurial experiments.

(*d*) Trials of sugarcane varieties suitable for growth without irrigation for various classes of soils and with ripening dates corresponding to the alteration in factory conditions.

(*e*) Rotational experiments.

(*f*) Crop experiments in collaboration with Sectional Officers.

9. Training of post-graduate students.

10. Touring and advisory.

APPEN

TABLE

Showing average yield per day (in lb.) and per cow per day

	July		August		September		October		November	
	C. B.	Sah.	C. B.	Sah.	C. B.	Sah.	C. B.	Sah.	C. B.	Sah.
1921-22										
No. of cows in milk	25	72	25	83	26	78	27	73	26	64
Average yield per day	475	572	439	385	348	552	371	427	406	328
Average yield per cow per day	19	8	17	7	13	7	14	6	16	5
1922-23										
No. of cows in milk	32	40	31	40	30	42	30	40	27	44
Average yield per day	562	382	499	383	410	373	408	366	401	402
Average yield per cow per day	17	10	16	10	14	9	14	9	15	9
1923-24										
No. of cows in milk	34	53	35	50	38	46	40	44	39	42
Average yield per day	453	508	481	475	474	428	519	406	487	366
Average yield per cow per day	13	10	14	10	12	9	13	9	12	9
1924-25										
No. of cows in milk	37	54	35	51	42	51	40	51	47	44
Average yield per day	617	621	548	561	608	529	548	499	663	396
Average yield per cow per day	17	12	16	11	14	10	14	10	14	9
1925-26										
No. of cows in milk	43	37	40	39	40	36	41	33	45	31
Average yield per day	733	485	599	495	574	445	671	386	821	370
Average yield per cow per day	17	13	15	13	14	12	16	12	18	12
1926-27										
No. of cows in milk	37	38	31	42	27	41	29	40	36	41
Average yield per day	711	524	576	571	501	556	610	488	806	444
Average yield per cow per day	19	14	19	14	19	14	21	12	22	11
1927-28										
No. of cows in milk	39	42	37	44	32	46	32	45	34	40
Average yield per day	719	494	653	515	559	583	609	535	699	435
Average yield per cow per day	18	12	18	12	17	13	19	12	21	11
1928-29										
No. of cows in milk	41	27	42	28	43	32	42	30	38	29
Average yield per day	795	436	771	421	740	446	771	446	720	410
Average yield per cow per day	19	16	18	15	17	14	18	15	19	14
1929-30										
No. of cows in milk	35	30	30	29	30	28	36	26	38	26
Average yield per day	612	407	585	393	584	358	663	288	667	270
Average yield per cow per day	17	14	19	14	19	13	18	11	18	10
1930-31										
No. of cows in milk	28	33	26	34	25	38	23	39	25	32
Average yield per day	520	480	455	471	433	469	391	435	406	319
Average yield per cow per day	19	15	17	14	17	12	17	11	16	10
1931-32										
No. of cows in milk	21	33	20	33	20	38	18	43	17	42
Average yield per day	485	424	436	439	416	512	403	535	416	472
Average yield per cow per day	23	13	22	13	21	14	22	12	24	11

DIX

I

of Cross-bred and Sahiwal cows from 1921-22 to 1931-32

December		January		February		March		April		May		June	
C. B.	Sah.	C. B.	Sah.	C. B.	Sah.	C. B.	Sah.	C. B.	Sah.	C. B.	Sah.	C. B.	Sah.
29	58	32	52	35	54	30	47	28	47	32	41	32	42
469	369	525	416	586	461	479	439	460	460	545	444	571	433
16	6	16	8	16	9	16	9	16	10	18	11	18	10
27	45	32	50	37	53	36	51	36	52	36	56	35	55
452	421	593	439	658	515	632	554	580	553	509	533	433	491
17	9	18	9	18	10	17	11	16	11	14	10	12	9
36	38	34	41	33	41	35	41	39	43	40	47	38	52
525	351	543	446	587	497	694	513	736	550	731	606	649	645
15	9	16	11	18	12	20	13	19	13	18	13	17	12
49	47	44	42	45	44	43	35	48	37	50	39	47	38
753	438	795	430	828	495	934	476	939	489	888	489	824	464
15	9	18	10	18	11	22	14	19	13	18	13	17	12
47	29	45	29	44	29	41	31	40	25	40	30	43	30
889	349	913	335	898	332	800	340	764	316	747	384	760	424
19	12	20	12	20	11	19	11	19	13	19	13	18	14
38	41	39	41	37	37	37	37	37	35	40	34	42	39
835	401	824	366	785	343	805	371	801	451	803	429	798	514
22	10	21	9	21	9	22	10	22	13	20	13	19	13
39	39	40	33	40	32	39	32	40	29	40	31	40	33
828	431	865	388	925	381	847	392	816	445	831	461	868	533
21	11	22	12	23	12	22	12	20	15	21	15	22	16
45	27	47	29	47	26	47	24	45	23	42	27	39	33
897	375	1009	370	1075	349	1044	343	908	345	837	383	712	458
20	14	21	13	23	13	22	14	20	15	20	14	18	14
36	27	42	29	48	26	57	27	60	29	54	29	36	31
727	275	989	303	1106	301	1339	356	1204	382	1065	411	672	464
20	10	23	10	23	12	23	13	20	13	20	14	19	15
26	29	22	31	22	30	23	28	23	27	25	31	25	32
561	330	560	438	518	433	513	394	540	379	573	418	565	410
22	11	25	14	23	14	22	14	23	14	23	14	23	13
17	39	18	38	18	40	17	41	16	42	14	44	12	44
473	422	475	436	461	490	422	571	344	690	313	765	375	787
28	11	26	12	26	12	25	14	21	16	22	17	23	18

Table II

Some of the selected Sahiwal cows which completed their lactation during the year 1931-32

Serial No.	Name of cow	No.	Date of birth	No. of calving	Quantity of milk given	
					lb.	days
1	Chengi . . .	534	11th November 1925	2	6,681	(304)
2	Tutia . . .	318	5th February 1917	9	5,707	(304)
3	Lakhni . . .	587	8th May 1928 .	1	5,582	(305)
4	Mukta . . .	472	27th June 1923 .	3	5,536	(304)
5	Roopbati . .	508	12th July 1924 .	3	5,488	(304)
6	Makhi . . .	557	14th October 1926 .	2	5,478	(303)
7	Ramati . . .	566	19th March 1927 .	1	5,066	(306)
8	Babni . . .	576	12th August 1927 .	1	4,201	(305)
9	Ajbi . . .	567	10th May 1927 .	1	4,014	(303)

Table III

Showing the percentage of mortality amongst the calves for 1930-31 and 1931-32

Year	Births			Deaths			Percentage of mortality
	Montgomery	Cross-bred	Total	Montgomery	Cross-bred	Total	
1930-31 . .	47	33	80	3	1	4	5·0
1931-32 . .	68	18	86	2	1	3	3·5

TABLE IV

Showing milk yield of Sahiwal cows for 1931-32

Month	SAHIWAL COWS						
	Yield	Average yield per day	Average yield per cow per day	No OF COWS IN MILK AND DRY			
				Total	In milk	Dry	Per cent. in milk
	lb.	lb.	lb.				
July 1931	13,145	424	12·8	76	33	43	43·4
August 1931	13,597	439	13·3	79	33	46	41·8
September 1931	15,372	512	13·5	80	38	42	47·5
October 1931	16,598	535	12·4	80	43	37	53·7
November 1931	14,151	472	11·2	80	42	38	52·5
December 1931	13,079	422	10·8	76	39	37	51·3
January 1932	13,518	436	11·5	75	38	37	50·7
February 1932	14,210	490	12·2	78	40	38	51·3
March 1932	17,693	571	13·9	82	41	41	50·0
April 1932	20,716	690	*16·4*	82	42	40	51·2
May 1932	23,721	765	*17·4*	81	44	37	54·3
June 1932	23,610	787	*17·9*	81	44	37	54·3
Average per month	16,617	545	13·6	79	40	39	50·2
Average for 1930-31	12,614	415	13·0	70	32	38	45·7

TABLE V

Showing the disposal of cattle during 1931-32

No. of animals	Description	Total price	Average per head
		Rs.	Rs. A.
17	½-Ayr.-Sahiwal cows	4,100	241 3
4	Pure Sahiwal cows	81	20 4
4	Pure Sahiwal heifers	159	39 12
4	Pure Sahiwal bulls and young bulls	400	100 0
14 (7 prs.)	Cross-bred steerlings	350	50 0 per pair
20	Sahiwal draught animals	760	38 0
	TOTAL	5,850	

REPORT OF THE IMPERIAL ECONOMIC BOTANIST

(F. J. F. Shaw, D.Sc., A.R.C.S., F.L.S.)

(1) BOTANICAL SECTION, PUSA

I. ADMINISTRATION

Dr. Shaw was on leave and Khan Sahib Abdur Rahman Khan held charge of the Section until the 18th October, 1931, when Dr. Shaw returned to duty. Khan Sahib Abdur Rahman Khan was then transferred to the Botanical Sub-station, Karnal, as Superintendent, and Babu Kashi Ram was appointed to officiate as First Assistant. The post of Special Research Assistant was sanctioned in the Class II grade for another year and Mr. R. D. Bose continued to hold this post. Mr. R. B. Deshpande was awarded the degree of M.Ag. with distinction by the University of Bombay for his research on the genetics of *Capsicum*.

A sum of about Rs. 1,195 was realized mostly from the sale of improved seeds and credited to Government. Most of the work of multiplying and distributing seed of improved types of crops was carried out on the Pusa Farm in collaboration with the Imperial Agriculturist.

Training

Messrs. A. R. Akhtar, M.Sc., M.B.V. Narasingarao, B.A., B.Sc., and T. R. Mehta, B.Sc., completed their post-graduate training in this Section in October 1931. At the end of this period of training, Mr. Akhtar was appointed a temporary Assistant to the Imperial Economic Botanist and was deputed to the Botanical Sub-station, Karnal; he resigned this post later to take up a Class II appointment as Assistant Rice Botanist in Bihar and Orissa. Mr. T. R. Mehta has since been appointed a Senior Assistant to the Paddy Specialist in the United Provinces. Mr. Narasingarao resumed charge of his duties as an Assistant in the Paddy Section at Maruter in Madras.

Mr. P. D. Dixit was appointed Senior Research Assistant to the Rice Specialist, Bihar and Orissa.

Messrs. R. Vasudeva Rao, L. Ag., D. C. Agarwala, L. Ag., and R. G. Joglekar, B.Ag., continued their course during the year under review and rendered material help in the different problems to which each of them was attached.

Mr. S. Majid, B.Sc., and Mr. R. P. Trivedi, M.Sc., were admitted this year for the full post-graduate course, but the latter left this Section after some time to take up an appointment as Junior Assistant to the Rice Specialist, Bihar and Orissa.

One student from the Agricultural Section and one Senior Assistant from the Mycological Section were permitted to attend

the usual course of lectures delivered by the Imperial Economic Botanist in biometry and field trials.

Two dairy students were given a short course of instruction in this Section.

Mr. W. Sayer, Officiating Imperial Agriculturist, permitted the post-graduate students of the Botanical Section to attend his field lectures on the cultivation of sugarcane and the threshing of cereals.

Season and Rainfall

The rains commenced rather late. The total annual rainfall remained below the average for the last 25 years by 7·01 inches. The distribution was not good, the month of July alone getting more than half the total rainfall. A very small amount of rust appeared; the incidence of this disease was restricted by the low rainfall in the cold weather.

Statement of rain in the Botanical Section in 1931-32

Month	Average for 25 years 1906-1930	From 1st June, 1931, to 31st May, 1932	Difference
June	7·53	1·45	—6·08
July	11·08	26·28	+15·20
August	14·09	4·70	—9·39
September	8·05	3·96	—4·09
October	1·81	2·34	+0·53
November	0·43	0·26	—0·17
December	0·18	0·03	—0·15
January	0·34	0·00	—0·34
February	0·68	0·28	—0·40
March	0·41	0·00	—0·41
April	0·56	0·00	—0·56
May	1·44	0·29	—1·15
Total	46·60	39·59	—7·01

Seed Distribution

Most of the improved seeds evolved by the Botanical Section were multiplied on the Pusa Farm as all the land in the Botanical Area was required for research and training.

Statement showing the seed distribution of improved crops evolved in the Botanical Section, Pusa

Crop	Variety	By the Botanical Section, Pusa	By the Pusa Farm	Total
		lb.	lb.	lb.
Wheat	Pusa 4	168	5,307	5,475
	Pusa 12	124	3,324	3,448
	Pusa 52	373	6,283	6,656
	Pusa 80-5	515	..	515
	Pusa 101	410	..	410
	Pusa 111	48	2,472	2,520
	Pusa 114	389	..	389
	Pusa 115	61	..	61
Barley	Type 7	41	..	41
	Type 21	827	7,001	7,828
Oat	Hybrid C	176	..	176
	,, F	51	..	51
	,, J	71	..	71
	B. S. 1	2,046	15,212	17,258
	B. S. 2	26	164	190
Gram	Type 6	90	..	90
	Type 17	2,534	..	2,534
	Type 25	620	..	620
	Type 28	89	..	89
	Type 58	203	..	203
Rahar	Type 15	21	..	21
	Type 16	141	216	357
	Type 24	127	..	127
	Type 64	8	..	8
	Type 69	7	41	48
	Type 80	2,035	..	2,035
	Type 82	143	82	225
	Type 87	250	..	250

Statement showing the seed distribution of improved crops evolved in the Botanical Section, Pusa—concld.

Crop	Variety	By the Botanical Section, Pusa	By the Pusa Farm	Total
		lb.	lb.	lb.
Linseed	Type 12	403	..	403
	Type 121	383	..	383
	Type 124	329	..	329
	Hybrid 10	13	..	13
Patwa	Type 3	8	..	8
	Type 6	5	..	5
	New Type	207	..	207
Tobacco	Type 28	9	..	9
	Hybrid 177	12	..	12
Sesamum	Type 3	3	..	3
	Type 29	31	..	31

II. INVESTIGATIONS

Wheat (*Triticum vulgare* L.)

The year under report was characterised by a particularly dry season during the cold weather and this was reflected in the freedom of the wheat crop from rust and the resulting excellent quality of the grain. The bushel weights of the wheats grown at Pusa bear witness to the quality of the grain in this year:—

Wheat	Weight per bushel in lb.	
	Average of past 6 years	1931-32
Pusa 4	63·5	66·1
„ 12	61·35	65·0
„ 52	63·94	66·5
„ 111	..	66·2
„ 101	..	66·8
„ 114	..	66·7

In collaboration with the Department of Agriculture, Sind, further milling and baking tests with Pusa wheats grown in Pusa and Sind and with some Sind wheats grown in Sind were carried out. These tests were carried out in the United States of America and indicate that Pusa 114 is the best wheat for Sind. This wheat had, in these tests, a protein content of 15·45 per cent., the next best in this respect being Pusa 111 which was very favourably reported on in the milling and baking tests performed in the United Kingdom last year. Some of the Sind selections (*e.g.*, H. S. W. III) had a good protein content and give under Sind conditions a high yield of grain. Punjab 8A proved low in protein content and yield of flour. Taking all the results together, it seems that the wheats which are most suitable for Sind are Pusa 114 and the Sind selections H.S.W. III and C.P.H. 47. All the available seed of Pusa 114 at Karnal has been purchased by the Sind Agricultural Department.

Single plant cultures from the crosses between Federation and Pusa 4, and Federation and Pusa 52, were continued, and detailed observations on the uniformity of culture were taken. Only two cultures have failed to breed true and have been rejected. Selections from the remainder are being tested for yielding power at Pusa and Karnal.

Observations at Karnal have shown that the wheat Pusa 52, which is so well suited to Bihar conditions, is of very little use under irrigated conditions.

Barley (*Hordeum vulgare* L.)

As a feed-barley Type 21 has done very well in Bihar. The following yields have been obtained in fields of average fertility and under unirrigated conditions at Pusa in the year under report:—

Variety	Plot	Area in acres	Yield in lb. per acre
Barley Type 21 . .	Pentagonal, W. Border .	0·13	2,462
Ditto . .	Musahar, Out No. 5 .	0·28	2,343
Ditto . .	Musahar, Out No. 6 .	0·26	2,531

A yield trial on the strip method was run this year in the Pusa Farm with the best type of barley evolved at Pusa and the best form isolated by the United Provinces Department of Agriculture. Pusa Type 21 and Cawnpur Type 251 were selected for

the purpose. These were put in contiguous strips in a plot two acres in area and the following yields were obtained:—

Total yields in lb. in 28 pairs of contiguous plots (Area of each plot = 0·028 acre)		Difference in yields in lb.	Mean difference	Standard error
Pusa Type 21	Cawnpur Type 251			
1,871·7	1,697·4	174·3	6·225	1·9213

For $n=27$ and $P=0·01$, the value of t from Fisher's tables is 2·771. The critical difference (Standard error $\times t$) for this experiment therefore is $1·9213 \times 2·771$ or 5·324 which is less than the observed difference of 6·225. Hence the difference is statistically significant in favour of Pusa barley Type 21.

The difference is about 10 per cent. and the yields obtained work out to average yields of 2,387·37 lb. and 2,165·05 lb. per acre for Pusa Type 21 and Cawnpur Type 251 respectively. A simultaneous trial was arranged to be run at Raya Farm in the United Provinces but through some misunderstanding the area was not laid out there in this manner, but one-acre blocks of the two types were put in instead. Although an experiment such as this furnishes no reliable idea of the yielding capacity of these two types of barley the following yields have been reported:—

Yield per acre of Pusa Type 21 . . . . 2,610 lb.
Yield per acre of Cawnpur Type 251 . . . 2,511 lb.

It must be remembered that at Pusa barley is never irrigated, whereas in the United Provinces three to four irrigations are given.

Although Type 21 barley has maintained its reputation for plumpness of grain and high yields, it appears to be not very suitable for malting and brewing purposes because of the purplish tinge present on the seed surface. Fifty maunds of this barley were sent to the Solon Brewery, Simla Hills, for malting tests, and it is reported that the purplish colour of the grain is a limiting factor in the use of this type as it imparts an undesirable tint to beer. Some cross-bred forms studied this year in the F_2 generation show promise of combining the high yielding power of the Type 21 parent and the white colour of the seed of the other parents. They may therefore furnish material for producing a good type of malting barley.

Helminthosporium attack on some of the barley types has been rather bad in late years. An experiment was conducted during the year, with the collaboration of the Mycological Section, to

study the efficacy of formalin and uspulun treatments on the different types. It was found that the uspulun treatment was more effective than the formalin treatment in controlling this disease. The result of this and another experiment to see the effect of various treatments on some Pusa barleys is given in detail in the report of the Imperial Mycologist.

Oats (*Avena sterilis* L.)

The study of hybrid oats evolved in this Section has progressed so far as to demand regular comparative trials for final selection. A number of promising hybrids were therefore tried this year in randomized blocks simultaneously at Pusa and Karnal and furnished very interesting results. This crop is not irrigated at Pusa but receives irrigation at Karnal. Whereas in preliminary trials in the last two years most of the hybrids selected for this experiment gave higher yields than B.S. 1 and B.S. 2 oats, the unusually dry season at Pusa during the year under report turned the table against the hybrids and B.S. 1 and B.S. 2 selections out-yielded all the hybrids. It is presumed that insufficient soil-moisture prevented the hybrids, which are almost all more vigorous and have a very high tillering power than the selections, from realizing their full and normal growth. At Karnal, however, where the crop was irrigated the hybrids maintained their superiority over the B.S. selections and confirmed the results usually obtained at Pusa in years of normal rainfall. The following table shows the result of these trials:—

Result of yield trial experiments with oats at Pusa and Karnal, 1931-32

Locality	Average yields in pounds per acre													Standard error of mean difference
	Hybrids.											B. S. 1	B. S. 2	
	A	B	C	D	E	F	G	H	I	J	K			
Pusa .	1,110·0	1,074·0	1,061·0	1,145·0	1,346·0	1,515·0	1,316·0	967·0	1,014·0	1,387·0	1,183·0	1,926·0	1,406·0	129·15
Karnal .	1,799·0	1,276·3	1,833·9	1,708·5	1,555·1	1,498·5	1,903·6	1,589·9	1,428·8	1,929·7	1,716·3	1,385·2	1,550·7	122·82
Rank as regards yielding power at														
Pusa . .	9th	10th	11th	8th	5th	2nd	6th	13th	12th	4th	7th	1st	3rd	..
Karnal .	4th	13th	3rd	5th	8th	10th	2nd	7th	11th	1st	6th	12th	9th	..

This trial affords sufficient evidence of the importance of running regular yield trials at different localities for a number of years before any definite and reliable conclusions can be drawn regarding the superiority of any particular type against some standard type. These trials will, therefore, be repeated again and some of the more promising hybrids will be distributed to reliable growers for trial under ordinary field conditions in various localities. Hybrids C and J have promised well and in addition to plump grain and good tillering they yield a high quantity of straw. Hybrids A and B are being rejected this year owing to their susceptibility to smut.

Paddy (*Oryza sativa* L.)

The single plant cultures of Bihar paddies were studied in detail. Duplicate and splitting cultures were rejected and the number of cultures has now been reduced from 700 to about 150. The classification of the cultures is being completed during the present year.

Gram (*Cicer arietinum* L.)

All the eighty-four types were maintained in culture and a preliminary varietal trial with two of the new types (Type 51 and Type 58) in comparison with the old established Type 17 was carried out. The results showed a decisive superiority in yielding power for Type 58 over Type 17, but Type 51 was not significantly superior to Type 17. The experiment was laid out in strips with six replications and the results may be summarized as follows:—

	Type 58	Type 51
Mean difference from Type 17 in pounds per strip .	+7·520	+1·645
Standard error	1·045	1·099
Critical difference for P = ·01	4·212	4·433
Critical difference for P = ·05	2·686	2·827

The statistical test of the results shows that only one in a hundred trials would chance produce a difference as large as 4·212 lb. in the case of Type 58. Since Type 58 has a mean difference from Type 17 of +7·52 this experiment shows that Type 58 is decisively superior to Type 17. These yield trials will be repeated.

The hybridization work with gram was transferred to Karnal and is described in the report of that Sub-station.

The morphology and cytology of the giant mutation in Type 22 which has been mentioned in previous reports has been the subject of a paper. The chromosome number in the mutation is reported to be two more than in the parent type. This case of gigantism therefore falls into line with similar cases in other species.

Pigeon-pea (*Cajanus indicus* Spreng.)

The isolation of the types was finished last year and a paper on these was written up and sent for publication. Eighty-six types have been isolated and these vary in many characters as mentioned below. Flowers are yellow or pale yellow, possessing no red colour, or having red colour present on the dorsal side of standard, in the veins or diffused in different forms. Pods are either green, green and red, or green and black. Seeds are white, silver-white with grey or brown marks, silver-white with purple markings, brownish red, fawn with brown markings, brownish fawn, greyish fawn, dark olive grey or black. Plant habit is mainly divided into two classes, *viz.*, erect and spreading. The erect types are generally preferred to spreading types, because the former allow interculture to be done easily and do not interfere with the growth of maize which is usually grown mixed with *rahar*. Two types of the inflorescence are met with. In one, the flowers and consequently the pods are borne close together and appear in clusters; in the other type, these are more apart and look scattered on the branches. The types also differ in stem colour, maturity, height, pod and seed size, etc., but the first importance in the classification has been given to the morphological characters of flowers, seeds and pods.

A case of what appears to be bud variation occurred in a single individual of Type 5. Type 5 possesses an inflorescence of the clustered type and in this individual plant some branches appeared with the open type of inflorescence. Seed has been taken from both types of branches and the subject is being investigated.

The yielding capacity of the promising types is being tested. Yield trial experiments were conducted on the Pusa Farm during the year under report and Types 24 and 51 gave the best results in these. Type 51 also possesses the erect habit and wilt-resisting quality and so appears very promising.

The new numbers of the types referred to in the previous annual reports by some numbers or letters are given below for reference:—

New numbers	4	5	15	16	24	25	41	50	51
Previous letters .	M	F	B	E	T	C	..	..	K
Previous numbers .	..	Type 1	22—1	80	..	..	136	99	87

New numbers	59	64	66	69	72	73	79	80	82
Previous letters .	H	S	..	A	P	D	R	A_2 or W R	G
Previous numbers .	..	..	172	..	..	..	..	..	163 or 204

The work on resistance to wilt disease, which has been carried out in collaboration with the Imperial Mycologist, was completed, and a joint paper written in collaboration with Dr. McRae has been submitted for publication. In addition to the original wilt-resistant types 80 and 82, several other types, 16, 41, 50 and 51, have been found to possess wilt resistance. As these types vary in their morphological characters, and from the evidence of crosses, it is considered that there is no definite correlation between morphological characters and wilt resistance.

Further work on resistance to wilt disease is being carried out as a study of the inheritance of the resistant property. Up-to-date results indicate that the property of resistance is inherited independently of morphological characters. In the cross between Type 80 and Type 5 pure breeding resistant hybrids have been obtained which possess the morphological characters of the susceptible parent. A relatively large area is being devoted to this work in the coming season.

Peas (*Pisum sativum* L. and *Pisum arvense* L.)

The tentative classification of last year was checked and the isolation of the types will be finished next year. Some *sativum* and *arvense* types were grown without support of sticks and the promising ones will be tried again in the coming season. *Sativum*

No. 14-1 is a garden pea having dwarf plants and large wrinkled seeds. It has given good yield when grown without sticks and will be multiplied for distribution.

Lentils (*Ervum lens* L.)

The study of the inheritance of flower and seed colour was continued this year and some very promising forms with bold seed have been evolved. These will be tried for yielding power in the ensuing season. It may be pointed out that the bold-seeded lentils usually give but poor returns: this is shown from the results given below obtained this year in the Pusa Farm:—

Type	Nature of seed	Area in acres	Yield in pounds
Type 19	Small .	0·5	418
„ III-86	Bold .	0·5	301

Urid and Mung (*Phaseolus Mungo* L. and *P. radiatus*)

Twenty-five types of *urid* and forty types of *mung* have finally been selected and classified, and two papers embodying this work have been submitted for publication.

A study of the root-systems of the selected types of these two pulses was made and after another year's observations an attempt will be made to correlate some important characters with the root-systems of the *urid* and *mung* plants.

In North Bihar, round about Pusa, *mung* is generally sown in February although in most other parts of India it is put in, like *urid*, after the break of rains. A number of types were, therefore, sown this year in July and although the foliage growth was mostly very good, invariably all the types failed to set a normal amount of seed. It is possible that incessant rains during the monsoon months under Pusa conditions are responsible for this, as too much water seems to have a deleterious effect and favours vigorous foliage growth at the expense of seed formation.

Sann-hemp (*Crotalaria juncea* L.)

The growing importance of this crop for fibre purposes demands a detailed study and the isolation of a suitable strain. Recently sann-hemp has begun to be used on a larger scale as a substitute for Russian hemp (*Cannabis sativa*), which is difficult to obtain owing to the great decrease in the production since the war and the increased utilization of the smaller output by Russia itself. Sann-hemp is also gaining popularity for green-manuring. A

large number of samples have been collected from almost all the provinces in India including Burma. These were grown this year and single plant selections from this material have been made. Unlike most other crops studied in this Section, sann-hemp is a cross-fertilized crop not amenable to selfing. This will prove a limiting factor in the isolation of pure-breeding types.

There appears to be a good deal of variability in the amount of seed setting in the different cultures studied. Whereas most of the Upper-India samples showed good setting, the better fibre-yielding types obtained from Bombay, Central India and the Central Provinces set very little seed under Pusa conditions.

Tobacco (*Nicotiana tabacum* L.)

A paper describing types of indigenous tobaccos was prepared and submitted for publication. The work contains descriptions of eighteen new types and extends the work of a previous publication in which Types 1 to 51 were dealt with. A study of sterility in Type 56 was completed. In this type there is a heavy amount of flower shedding in the early stages of growth which is succeeded by good seed setting in the later stages; the viability of the seed is, however, not quite so high as in other types. The physiological causes of this have been investigated and the results will shortly be published.

The investigation upon the inheritance of characters in a cross between a white-flowered and a red-flowered type was not continued during the year under review owing to the absence at Karnal of the assistant who is carrying on this work. The F_3 generation will be grown during the coming season.

Further curing tests with Hybrid No. 142 were carried out and confirmed the results obtained in the previous season. Unfortunately owing to the severe incidence of leaf-curl disease in the year under review no definite conclusions could be drawn as regards the yielding power of this type. The cause of this disease is obscure—the last serious outbreak in the Section was in 1925-26; it may possibly be a virus disease.

Chillies (*Capsicum annuum* L. and *C. frutescens* L.)

The original types were maintained and the work of isolating unit species in Goa chillies was continued. The study of the reciprocal of the cross between Type 3 and Type 29 was completed and the results of this cross have now been written up for publication.

Hemp (*Hibiscus cannabinus* L. and *H. sabdariffa* L.)

The different types of both species were maintained in culture.

The study of crosses with the new *Hibiscus* (*H. sabdariffa* var. *altissima*) was continued, and the F_2 generations of the two crosses, *Albus* × new *Hibiscus* and *Ruber* × new *Hibiscus*, were grown. In both the crosses the ratio of bushy plants (like *Albus* or *Ruber*) to non-bushy (like new *Hibiscus* and F_1) was 1 : 3, and that of broad leaf lobed plants (*Albus* or *Ruber*) to narrow leaf lobed plants (new *Hibiscus* and F_1) was also as 1 : 3, suggesting a monohybrid segregation.

As regards stem colour in the cross *Albus* × new *Hibiscus* the ratio of red plants like F_1, red plants like new *Hibiscus* and plants like *Albus* was as 9 : 3 : 4 suggesting a dihybrid segregation, while in *Ruber* × new *Hibiscus* the proportion of red plants (of various intensity and extent) to plants like new *Hibiscus* was 3 : 1.

A number of F_2 plants have been selfed for the study of F_3 which it is hoped will throw further light on the mode of inheritance for the various characters.

The quantitative data for leaf-factor are being tabulated.

The Fibre Expert to the Government of Bengal, who grew the new Pusa *Hibiscus* (*H. sabdariffa* var. *altissima*) at Dacca, reported the high yield of 27 maunds per acre on a soil which was not particularly fertile. The fibre grown and retted by him at Dacca was examined in Calcutta at a meeting by balers, spinners and brokers. The general opinion was that the fibre is spinnable but would not be regularly accepted by mills for making gunnies. It was placed in the same class as "mesta"—*H. cannabinus*—and considered more suitable for rope making.

A sample of the fibre of the new Pusa hemp (*Hibiscus sabdariffa* var. *altissima*) was sent to a firm of rope manufacturers to test its suitability as a cordage fibre. The rope stood a strain of 12 cwt. The official standard requires a breaking strain of $15\frac{3}{4}$ cwt. for a manila rope of the same dimensions.

Linseed (*Linum usitatissimum* L.)

The seventh generation of hybrids from the crosses, the results of which have been published, and the fifth generation of another set of crosses consisting of Type 1 × Type 15, Type 12 × Type 15, Type 22 × Type 15, Type 1 × Type 102, and Pink × Type 1, were grown. The results of this latter set are yet to be described.

A yield trial experiment was run with five out of a number of promising hybrids and the standard Type 12 both in "Randomized Blocks" and "Latin Squares". An area of four acres was under the former, there being four blocks of six strips each (a strip being given to each variety). Each strip measured 429′ × 15′ or roughly 1/7 of an acre. One acre was given to the "Latin Squares" in which area two "Latin Squares" were laid out.

The plots measured 30′ × 20′ each, *i.e.*, roughly 1/70 of an acre. Plots were allocated to the varieties in the two "Latin Squares" independently by lots. Thus there were three different yield trial experiments. The results of all these experiments agree fairly closely. Type 12 proved the best yielder and Hybrid 10 and Hybrid 13 were second and third respectively in all the three trials. Hybrid 63 was fourth in two trials and fifth in the third. Hybrid 11 was fourth in one trial, fifth in another and sixth in the third. Hybrid 2 was fifth in one and sixth in two trials.

The second generations of the crosses—Type 15 × Type 4, Type 15 × Type 21, and Type 15 × Type 24—were grown and studied.

In the cross Type 15 × Type 21 (in which Type 15 has white and Type 21 blue petals), the F_1 was white and in F_2 a ratio of 3 white to 1 blue was obtained, suggesting dominance of white over blue, a condition the reverse of that observed in other crosses. A careful examination of the flowers of F_1, however, showed a very faint bluish tinge on the apex of the petals which was more clear in the buds. Many of the white F_2 segregates also showed this blue tinge and a correct diagnosis of the pure whites and the bluish whites was finally made by testing petals with hydrochloric acid. It was found that the acid caused the bluish petals to become pink. The ratio of those turning pink with acid to others not turning pink was nearly 2 : 1—the larger group is therefore the blue heterozygotes and the cross agrees with other crosses in the dominance of blue in the petal.

Some back-crosses and new crosses have been made with the above parental types in order to throw more light on the genetic constitution of the above types and particularly on that of Type 15.

The linseed and flax varieties received from Australia were grown for the second season in succession. Very late varieties either did not produce good, healthy seed or altogether failed to set. The work of isolation and fixing of varieties from amongst these was continued. Excepting Type 12 and Hybrid 26 all the rest of the samples (108) show an increase in oil-content.

The average oil-content of last year (1930-31) for 108 samples was 39·57 per cent. and that of 110 samples for this year (1931-32) is 42·75 per cent., *i.e.*, there is an increase of 3·18 per cent. in the oil-content this year over last year's figure.

The maximum oil-content in any sample was 43·50 per cent. for 1930-31 and that for 1931-32 is 47·42 per cent. Similarly the minimum oil-content for 1930-31 and 1931-32 was respectively 34·55 per cent. and 37·29 per cent. Thus there is an increase of 3·92 per cent. in the maximum and an increase of 2·74 per cent. in the minimum this year over the last year's figures.

Statement showing the oil percentage of some linseed hybrids and the standard types from 1928-29 to 1931-32 (4 years)

Variety	Oil percentage				
	1928-29	1929-30	1930-31	1931-32	Mean
Type 12	36·67	36·93	37·68	37·29	37·14
„ 121	40·01	40·13	38·88	41·50	40·13
„ 124	38·22	39·86	37·44	42·30	39·45
H. 2 (Type 1 × Type 12) .	40·99	40·47	40·78	45·07	41·83
H. 10 (Type 12 × Type 1) .	43·00	42·20	41·49	45·50	43·05
H. 11 („ „ „) .	43·13	43·25	43·50	46·55	44·11
H. 13 („ „ „) .	40·14	39·49	39·32	41·79	40·18
H. 63 (Type 121 × Type 11)	44·64	41·52	43·37	44·91	43·61

Safflower (*Carthamus tinctorius* L.)

The various types were maintained.

The selfed seed of the normal (green) and the variegated segregates arising from a variegated plant found in Type 27 in 1929-30 were sown. All the normal segregates bred true but the seeds of the variegated segregates were scantily produced and failed to germinate.

Til (*Sesamum indicum* D.C.)

Further observations on the F_2 generation of a cross between Type 3 and Type 29 were taken. The work will be continued to later generations in the following seasons.

Brassica

Last year the Brassicas were tentatively divided into nine groups, and out of these only three were found self-fertile, *viz.*, (1) yellow *sarson* (*B. campestris* var. *sarson* Prain); (2) *rai* (B. *juncea* Hooker); (3) Chinese mustard (*B. Rugosa* var. *cuneifolia* Prain). The isolation of pure types was, therefore, confined to these three groups, while the problem of evolving practically pure strains was taken up in the case of self-sterile groups. The tentative classifications of the types in the different self-fertile groups have been made and will be checked next year.

The crosses between the different groups that were attempted last year were studied in the F_1 generation. No seed was formed under bag in the F_1 plants of the crosses between the sterile groups.

The F_2 of some self-fertile hybrids will be grown next year in order to study the inheritance of self-fertility.

An investigation on the causes of sterility was carried out and the results have been published.

Most of the varieties under investigation were self-sterile, and the amount of setting in cross-pollinations was much higher than in self-pollinations. Self-sterile varieties could be made to set a good amount of seed when buds (1 to 2 days before opening) were selfed with pollen from different branches, but the progeny of self-fertilized seed seemed to lose vigour and fertility. It was shown that in cross-pollinations (compatible matings) the pollen tube reached the ovary in a shorter time than in self-pollinations (incompatible matings) and that the sterility in incompatible matings was due to the failure of the pollen tube to reach the ovule before it had lost its receptive power. The self-sterile varieties were adapted to cross-fertilization, which was brought about by bees that visited the flowers in large numbers on sunny days. It was probably due to the cross-fertilization that the vigour and the fertility of these sterile varieties was maintained.

Taramira (*Eruca sativa* L.)

The study of sterility in relation to the homozygous nature of plants was continued as mentioned in the last year's report.

III. OUTTURN STATEMENTS OF DIFFERENT CROPS

1. Statement showing the yield of crops in the Botanical Section in 1931-32

Crop	Plot	Area in acres	Outturn of grain in lb.		Remarks
			Actual	Per acre	
Wheat—					
P. 4 . .	S. T. G. 1 . .	0·51	854	1,686	
P. 12 . .	Riverbank East .	0·76	1,455	1,914	
P. 52 . .	S. T. G. 2 . .	0·53	1,011	1,906	
P. 101 .	Musahar inside . .	0·60	566	943	
P. 111 .	S. T. G. 3 . .	0·51	826	1,620	
P. 114 .	Barah 1 part . .	0·43	826	1,921	
P. 115 .	Ditto . .	0·46	943	2,050	
P. 163 .	Ditto . .	0·49	858	1,751	Rejected.

1. STATEMENT SHOWING THE YIELD OF CROPS IN THE BOTANICAL SECTION IN 1931-32—*contd.*

Crop	Plot	Area in acres	Outturn of grain in lb.		Remarks
			Actual	Per acre	
Oats—					
B. S. 1 .	Orchard 5B . .	0·60	1,422	2,370	
B. S. 2 .	Lawnplot 3 . .	0·18	471	2,617	
Hybrid C .	,, 3 . .	0·12	281	2,342	
,, A .	Pentagonal border East.	0·11	164	1,491	
Barley—					
Type 21 .	Pentagonal border West.	0·13	320	2,462	
,, 21 .	Musahar outside No. 5	0·28	656	2,343	
,, 21 .	Do. No. 6	0·26	658	2,531	
Linseed—					
Type 12 .	Barah 3 . . .	0·85	682	802	
,, 121 .	,, 7 . . .	0·49	529	1,082	
,, 124 .	N. T. G. 9 . .	0·40	244	611	
Gram—					
Type 17 .	N. T. G. 6 and 7 .	0·198	306	1,545	
,, 51 .	Ditto .	0·099	162	1,637	
,, 58 .	Ditto .	0·099	200	2,020	
,, 2 .	N. T. G. 5 part .	0·11	83	755	
,, 6 .	,, 5 part .	0·11	160	1,455	
,, 17 .	,, 8 . .	0·34	556	1,635	
,, 17 .	Pentagonal . .	4·22	3,051	723	Grown with Hibiscus
,, 25 .	Musahar inside 7 .	0·22	431	1,960	
,, 25 .	W. Orch. border D. .	0·09	145	1,611	
,, 25 .	S. T. G. 4 . .	0·30	252	840	Grown after maize

1. STATEMENT SHOWING THE YIELD OF CROPS IN THE BOTANICAL SECTION IN 1931-32—*concld.*

Crop	Plot	Area in acres	Outturn of grain in lb.		Remarks
			Actual	Per acre	
Gram—concld.					
Type 58	Musahar inside 6	0·22	314	1,427	
„ 33	N. T. G. 5 part	0·11	164	1,491	
„ 51	Ditto	0·11	165	1,500	
„ 26	Musahar inside 9	0·11	88	800	
„ 28	„ „ 8	0·11	226	2,055	
Hibiscus—					
Type 3	Musahar outside 4	0·28	30	104	
„ 6	„ „ 7	0·26	61	235	
New Patwa.	Riverbank West part.	0·50	98	196	
Ditto	Ditto	0·74	826	1,116*	* Fibre
Lentil—					
Type 11	Orchard 1A part	0·36	225	625	
Rahar—					
Type 69	Musahar inside 1	0·22	96	436	Old numbers =A
„ 15	„ „ 2	0·22	209	950	=B
„ 16	„ „ 3	0·22	278	1,264	=E
„ 82	„ outside 1	0·30	410	1,367	=G,163 or 204
„ 64	„ „ 2	0·29	339	1,169	=S
„ 24	„ „ 3	0·29	287	990	=T
„ 51	„ „ 5	0·22	339	1,541	=87 or K
„ 80	Orchard 4 A	2·03	2,421	1,193	=A2
Sanai for seed.	Farm plot	1·0	1,124	1,124	
Tobacco—					
Hybrid 142	Orchard 2 B	0·62	287	463	Leaf
„ 142	„ 2 C	0·71	366	516	„

2. Outturn of crops grown in the Farm but threshed in the Botanical Section in 1931-32

Crop	Plot	Area in acres	Outturn of grain in lb.	
			Actual	Per acre
Rahar—				
Type 69	Nepali	0·278	347	1,246
„ 15	„	0·278	399	1,435
„ 16	„	0·278	328	1,180
„ 59	„	0·278	345	1,239
„ 51	„	0·278	511	1,835
„ 82	„	0·278	431	1,550
„ 64	„	0·278	460	1,654
„ 41	„	0·278	327	1,174
„ 24	„	0·556	931	1,672
„ 5	„	0·556	718	1,289
„ 80	„	0·556	653	1,173
„ 82	„	0·556	774	1,390
Local	„	0·556	787	1,413
Linseed—				
Type 12	South Pungarbi part	0·83	521	628
H. 2	„ „ „	0·83	286	345
H. 10	„ „ „	0·83	353	426
H. 11	„ „ „	0·83	284	342
H. 13	„ „ „	0·83	326	393
H. 63	„ „ „	0·83	281	339
Hibiscus—				
New Patwa	Middle Pungarbi	1·00	383	383
Oats—				
Hybrid A	Jhilli (part)	0·115	159·3	1,385·9
„ B	„	0·115	154·1	1,340·7

2. Outturn of crops grown in the Farm but threshed in the Botanical Section in 1931-32—*concld.*

Crop	Plot	Area in acres	Outturn of grain in lb.	
			Actual	Per acre
Oats—concld.				
Hybrid C . .	Jhilli (part) . . .	0·115	152·2	1,324·1
„ D . .	„ . . .	0·115	164·3	1,429·4
„ E . .	„ . . .	0·115	193·1	1,680·0
„ F . .	„ . . .	0·115	217·3	1,890·5
„ G . .	„ . . .	0·115	188·8	1,642·6
„ H . .	„ . . .	0·115	138·7	1,206·7
„ I . .	„ . . .	0·115	145·5	1,265·8
„ J . .	„ . . .	0·115	199·0	1,731·3
„ K . .	„ . . .	0·115	169·7	1,476·4
(B. S. 1) L . .	„ . . .	0·115	276·3	2,403·8
(B. S. 2) M . .	„ . . .	0·115	201·7	1,754·8
B. S. 1 . .	„ . . .	0·37	685	1,851·4

3. Statement showing the outturns of improved varieties from the Botanical Section grown on Pusa Farm during 1931-32

Crop	Plot	Area in acres	Outturn of grain in lb.	
			Actual	Per acre
Wheat—				
Pusa 4 . . .	Middle Pangarbi . .	5·0	3,833	767
„ 12 . . .	Old Jhilli . . .	5·50	10,266	1,867
„ 52 . . .	„ „ . . .	5·0	8,534	1,707
„ 114 . . .	„ „ . . .	1·0	1,594	1,594
„ 111 . . .	Gonhri . . .	18·0	22,140	1,230
„ 80-5 . .	„	9·0	13,023	1,447

3. Statement showing the outturns of improved varieties from the Botanical Section grown on Pusa Farm during 1931-32 —*concld.*

Crop	Plot	Area in acres	Outturn of grain in lb.	
			Actual	Per acre
Wheal—concld.				
Pusa 115	Gonhri	9·0	11,418	1,269
„ 163	„	4·0	5,336	1,334
Barley—				
Type 21	Old Jhilli	1·0	1,899	1,899
Cawnpore 251	„ „	1·0	1,688	1,688
Type 21	South Pangarbi	5·0	9,489	1,898
Oats—				
B. S. 1	Mysore	14·50	11,949	824
B. S. 2	„	5·0	4,348	869
Lentil—				
Type 19	South Pangarbi	0·5	418	836
„ III-86	„ „	0·5	383	766
Gram—				
Type 17	Punjab "A" Block	2·0	2,137	1,068
„ 28	„ „ „	2·0	2,035	1,017
„ 25	„ „ „	2·0	2,468	1,234
„ 58	„ „ „	2·0	2,215	1,107

IV. PUBLICATIONS AND PROGRAMME OF WORK FOR 1932-33

Publications

1. S:3w, F. J. F. . The breeding of *Cicer* and *Cajanus*. *Imp. Bur. of Plant Genetics, Herbage Plants, Aberystwyth, Bull.* No. 7, 1932, 14-16.

2. Shaw, F. J. F., and Kashi Ram.	Studies in Indian Tobaccos, No. 7. The types of *Nicotiana tabacum* L. *Ind. Jour. Agri. Sci.*, 1932.
3. Shaw, F. J. F., Abdur Rahman Khan, and Hukam Singh.	Studies in Indian Pulses, No. 3. The types of *Cajanus indicus* Spreng. *Ind. Jour. Agri. Sci.*, 1932.
4. Shaw, F. J. F., and McRae, W.	Influence of manures on the wilt disease of *Cajanus indicus* Spreng. and the isolation of types resistant to the disease. *Scientific Monograph No. 7 of the Imperial Council of Agri. Res.*
5. Kashi Ram, and R. M. Row.	Some observations on the growth of *Sesamum indicum* in different soil conditions with special reference to root development. *Ind. Jour. Agri. Sci.*, 1931.
6. Bose, Rakhal Das .	Studies in Indian Pulses, No. 4. *Mung* or Green Gram (*Phaseolus radiatus L.*). *Ind. Jour. Agri. Sci.*, 1932.
7. Bose, Rakhal Das .	Studies in Indian Pulses, No. 5. *Urid* or Black Gram (*Phaseolus mungo* L. var. *Roxburghii* Prain). *Ind. Jour. Agri. Sci.*, 1932.
8. Bose, Rakhal Das .	Another yield trial with some Pusa Barleys. The Method of Analysis of Variance. *Agriculture and Livestock in India*, 1932.
9. Mehta, T. R. . .	Breeding disease-resistant crops. *Agriculture and Livestock in India*, 1931.
10. Akhtar, A. R. . .	Studies in Indian Brassicae, I. Sterility and selective pollen tube growth. *Ind. Jour. Agri. Sci.*, 1932.
11. Dixit, P. D. . .	A case of gigantism in gram (*Cicer arietinum* L.). *Ind. Jour. Agri. Sci.*, 1932.
12. Dixit, P. D. . .	A note on the cytology of Kabuli and Desi gram. *Ind. Jour. Agri. Sci.*, 1932.

Programme of work for 1932-33

Investigations will be continued on the genetics of those crops which have formed the subject of this report. Special attention will be given to yield trials and statistical methods. Training of students will continue as in past years.

(2) BOTANICAL SUB-STATION, KARNAL

I. INTRODUCTION

The station was opened in September 1930 and is administered as a part of the Botanical Section, Pusa, under the Imperial Economic Botanist. The first annual report of the sub-station (not published) dealt with the year ending March 31, 1931, but as this date is very inconvenient for the writing of an annual report on agricultural matters the present report covers the period from April 1, 1931, to June 30, 1932. Future reports will be issued for the year ending June 30.

II. CHARGE

Babu Kashi Ram, Second Assistant to Imperial Economic Botanist, held charge of the station as Officiating Superintendent until the 28th October, 1931, when Khan Sahib Abdur Rahman Khan was transferred from Pusa and took over the office of Superintendent.

All posts except that of an Assistant have been filled. Mr. A. R. Akhtar, Officiating Assistant to the Imperial Economic Botanist, was sent to Karnal from Pusa to assist the Superintendent in January 1932. Mr. Akhtar resigned his appointment in March 1932 to take up a post under the Bihar and Orissa Rice Scheme in April. Proposals for the recruitment of an Assistant have been submitted.

The following amounts realized by the sale of seeds, etc., were credited into the Karnal Treasury:—

	Rs.	A.	P.
Last year up to 30th June 1931 . . .	9	6	0
Year under report, from 1st July 1931 to 30th June 1932	1,250	7	9
TOTAL .	1,259	13	9

III. CONSTRUCTION AND LAYING OUT

The heaviest task in the year under review was the construction, lay out and organization of the area as a sub-station of the Botanical Section. This was commenced by Babu Kashi Ram and carried on by Khan Sahib Abdur Rahman Khan; most of the work was done while I was on leave and reflects great credit on both these officers.

The following buildings were completed during the year:—Laboratory and office, quarters for Superintendent, Farm Assistant, Fieldman, Clerk, Store-keeper, Head Mali, Mistri, two Assistant Malis, Peon, two watchmen and five ploughmen, bullock-gear shed, net house, threshing floor, implement shed and godown, mistri's shed (workshop) and general latrine.

For the present the Imperial Dairy Expert has given us temporary accommodation for bullocks and storing *bhusa*. It was hoped to adapt one of the old barracks for these needs but the P. W. Department having reported against the carrying out of extensive alterations and repairs to a barrack we shall be faced with the need of constructing bullock lines and godowns in the near future.

The sub-station consists of about 143 acres in four divisions:—

(1) General area—104 acres which gives about 87 acres for cultivation after deducting roads and water channels.

(2) Experimental area—21 acres, about 18 acres being under cultivation.

(3) Rice area—about 7 acres.

(4) Building area— about 11 acres.

The general area has been fenced and laid out in regular plots, with roads and irrigation channels. A good deal still remains to be done in making culverts, etc. The experimental area has been fenced and laid out in regular plots—this area is near the laboratories and is used for plant-breeding work and experiments which require close control and supervision. The general area is devoted to seed multiplication and yield trials which do not require such continuous attention.

The building and rice areas are not yet fenced. In the former, boring of the existing well was done in order to improve the water supply. The well was also fitted with a Persian wheel which is used for the irrigation of small cultures and experiments which require small quantities of water at frequent intervals and whose needs cannot be met by the general irrigation system.

IV. MACHINERY

A crude oil tractor was obtained for the sub-station, the Lanz "Bull Dog" being the type selected. The tractor worked satisfactorily both in running the "Consul" thresher and cultivating the land with three-furrow ploughs and disc harrow. It is worked with cheap crude oil. In a clayey loam soil like that of Karnal its running cost for ploughing comes roughly to Rs. 3 and for harrowing Rs. 1-8 per acre. The "Consul" thresher appears to be a great improvement over the old type threshing machines. The advantage with this thresher is that it bruises the straw simultaneously without any further addition to the cost of running. The bruised *bhusa* was as fine as could be made by the bullocks. This particular combination of bruisers with the thresher may meet the long standing want of those already engaged in handling bulky agricultural crops.

The thresher gave 100 maunds of clean wheat in 9 hours. The running expenses, including every item of expenditure, were Rs. 15-13, or about annas 2-6 per maund of grain which can be further lowered to annas 2 or even less if the oil is obtained at wholesale cheaper rates.

Practically all the various crops could be threshed with this thresher, but for its efficient working it may require special caving riddles and sieves to deal with different crops.

V. INVESTIGATIONS

In the report for 1930-31 the results of the experiments were not given as the year under report ended on the 31st March and harvest returns were not available at the time of writing that report. For this reason the results of two *rabi* harvests have been included in this report.

Kharif, 1931

Juar. Twenty-five acres of *juar* (sorghum) fodder were grown, out of which six acres were made into silage for the bullocks and the remaining 19 acres were transferred to the Imperial Cattle Breeding Farm, Karnal, free of charge.

Paddy. Seventy-six samples of paddy were collected from different places in the Punjab and other parts of India and were grown for isolation of different types suitable for the Karnal climate. Over 150 single plants were selected and will be grown next year.

Rabi, 1931 and 1932

Wheat. In 1930-31, Pusa hybrid 3-1 gave the highest outturn. Being a beardless wheat, it may not gain popularity among the local cultivators, but it may replace Pusa 12 or Pusa 4 in some localities. Among the bearded varieties Pusa 20-1 did better than Pusa 114 and Pusa 52 was the poorest. Unexpectedly wheats Pusa 52 and 115 were badly damaged by yellow rust. They are not damaged in this way in Bihar. They have also suffered a good deal in 1931-32 and it is possible that Pusa 52 is not suited to irrigated conditions at Karnal. Arrangements are being made to investigate the matter thoroughly in the next year.

In 1931-32, amongst the beardless varieties Pusa 163, 113, 3-1, and 80-5 have given very good results. Yield trials on a statistical basis will be necessary to establish the decisive superiority of these types. In bearded varieties Pusa 114 and 20-1 gave good outturn. Pusa 114 has given best results under Sind conditions and the Botanist in Sind has purchased all our seed for distribution. At Karnal it has a defect of shedding its grain when too ripe. Pusa 80-5 has done well at Kulu and the Deputy Director of Agriculture, Jullundur, has purchased all the seed we could supply for distribution there. The Extra Assistant Director of Agriculture, Karnal, reports that demand for Pusa 4 and Pusa 12 is very keen in his sub-circle.

Gram. All the types of gram and some crosses which were started at Pusa were grown at Karnal and are yielding interesting results.

Gram Type 13 having blue flowers was crossed with Types 9 and 11 both of which have white flowers. In the first case (Type

13 × Type 9) the F_1 had pink flowers and the F_2 segregated into pinks, blues and whites which suggests that pink colour in the flower depends upon two complementary factors, one of which alone produces blue colour while the other changes the blue into pink. In the other case (Type 11 × Type 13) the F_1 produced blue flowers and F_2 segregated into blues and whites giving a monohybrid ratio of 3 blues to 1 white. This shows that types producing white flowers are of two kinds, one like Type 9 which possesses a factor which changes blue into pink and the other like Type 11 which lacks this factor. Another cross between Type 82 which has double pink flowers and Type 1 which has single green flowers was studied. The F_1 produced single pink flowers showing that the factor of single flowers is dominant and the F_2 segregated into 3 single to 1 double flowered plant. An interesting fact is that F_2 has produced some white flowered plants of a new type as the parents have pink or green flowers. Some new crosses of gram have also been made.

In the variety trial Pusa 17 has given the best results.

Oats. A yield trial of some Pusa oats was laid out in randomised blocks. Eleven hybrid oats and B. S. 1 and 2 were included in the experiment. Plots 1,000 square feet in area replicated five times were put under each type. The results were analysed by the Analysis of Variance method and the following outturns per acre were obtained:—

Hybrids	Average yield in pounds per acre in						
	A	B	C	D	E	F	G
	1,799·0	1,276·3	1,833·9	1,768·5	1,555·1	1,498·5	1,903·6
Rank as regards yielding power.	4th	13th	3rd	5th	8th	10th	2nd

Hybrids	Average yield in pounds per acre in						Standard error of Mean difference.
	H	I	J	K	B. S. 1	B. S. 2	
	1,589·9	1,428·8	1,929·7	1,716·3	1,385·2	1,550·7	122·82
Rank as regards yielding power.	7th	11th	1st	6th	12th	9th	

The following table brings out the differences between the yields of various oat varieties and wherever these differences exceed ±7·5735 they may be taken to be statistically significant:—

Differences between yields of various oat varieties in Karnal yield trial, 1932

Varieties	A	B	C	D	E	F	G	H	I	J	K	L	M	Mean yield of each variety
A	..	−12·0	+0·8	−0·7	−5·6	−6·9	+2·4	−4·8	−8·5	+3·0	−1·9	−9·5	−5·7	41·3
B	+12·0	...	+12·8	+11·3	+6·4	+5·1	+14·4	+7·2	+3·5	+15·0	+10·1	+2·5	+6·3	29·3
C	−0·8	−12·8	...	−1·5	−6·4	−7·7	+1·6	−5·6	−9·3	+2·2	−2·7	−10·3	−6·5	42·1
D	+0·7	−11·3	+1·5	...	−4·9	−6·2	+3·1	−4·1	−7·8	+3·7	−1·2	−8·8	−5·0	40·6
E	+5·6	−6·4	+6·4	+4·9	...	−1·3	+8·0	+0·8	−2·9	+8·6	+3·7	−3·9	−0·1	35·7
F	+6·9	−5·1	+7·7	+6·2	+1·3	...	+9·3	+2·1	−1·6	+9·9	+5·0	−2·6	+1·2	34·4
G	−2·4	−14·4	−1·6	−3·1	−8·0	−9·3	...	−7·2	−10·9	+0·6	−4·3	−11·9	−8·1	43·7
H	+4·8	−7·2	+5·6	+4·1	−0·8	−2·1	+7·2	...	−3·7	+7·8	+2·9	−4·7	−0·9	36·5
I	+8·5	−3·5	+9·3	+7·8	+2·9	+1·6	+10·9	+3·7	...	+11·5	+6·6	−1·0	+2·8	32·8
J	−3·0	−15·0	−2·2	−3·7	−8·6	−9·9	−0·6	−7·8	−11·5	...	+4·9	+12·5	+8·7	44·3
K	+1·9	−10·1	+2·7	+1·2	−3·7	−5·0	+4·3	−2·9	−6·6	+4·9	...	−7·6	−3·8	39·4
L	+9·5	−2·5	+10·3	+8·8	+3·9	+2·6	+11·9	+4·7	+1·0	+12·5	+7·6	...	+3·8	31·8
M	+5·7	−6·3	+6·5	+5·0	+0·1	−1·2	+8·1	+0·9	−2·8	+8·7	+3·8	−3·8	...	35·6
Mean yield of each variety.	41·3	29·3	42·1	40·6	35·7	34·4	43·7	36·5	32·8	44·3	39·4	31·8	35·6	...

Standard error of Mean difference = 3·9766.
For P = ·01 t = 2·6847 for n = 48. Critical value of d = t × Std. error = 7·5735.
Differences in the above table higher than ±7·5735 are statistically significant.

These figures suggest the superiority of some hybrid oats over B. S. 1 and 2 selections under the conditions of the experiment.

Barley. The best Pusa barley Types 21 and 12 suffered very severely from yellow rust under irrigated condition and are probably useless at Karnal. Other types of barley will be tested next year.

Linseed. Three types of Pusa linseed and two hybrids were grown in the year under report. Type 12 gave the best results. Linseed is not grown in the Karnal district but it gives good outturn and may pay the cultivator better than wheat. The hybrids though better in size of grain are deficient in the yield per acre.

VI. SEED DISTRIBUTION

The following seeds were distributed from the harvests of 1930-31 and 1931-32:—

	Maunds
Harvest of 1930-31—	
Wheat, Pusa 52	57
,, ,, 114	6
Harvest of 1931-32—	
Wheat, Pusa 3—1	3
,, ,, 4	74
,, ,, 12	26
,, ,, 20—1	3
,, ,, 52	18
,, ,, 80—5	61
,, ,, 111	8
,, ,, 112	3
,, ,, 114	200
Oat, B. S. 1	4
Gram, Type 17	2

VII. STATEMENTS SHOWING THE YIELDS OF CROPS

1. Outturn of crops in 1930-31

Crop	Area in acres	Outturn of grain in lb.	
		Actual	Per acre
Wheat, Pusa 114	6·3	6,080	965
Wheat, Pusa 52	40·2	29,684	738
Barley, Type 21	12·7	9,020	710
Oats, B. S. 1	34·5	35,916	1,041

2. Results of wheat varieties grown in 1930-31

Wheat variety	Area in acres	Outturn of grain in lb.	
		Actual	Per acre
Pusa 52	0·27	164	607
Pusa 114	0·15	123	820
Hybrid 20—1	0·22	194	882
Hybrid 3—1	0·18	296	1,644

3. Statement showing the outturn of wheats grown in 1931-32

Crop	Plot	Area in acres	Outturn of grain in lb.		Bushel weight lb.
			Actual	Per acre	
General Area—					
Pusa 112	1 to 5	4·63	6,199	1,339	64·24
114	6 to 13	9·71	15,455	1,591	64·72
80-5	14 to 16	3·95	6,689	1,693	65·86
4	24 to 26	6·61	9,495	1,437	65·12
12	27 to 29	5·51	6,433	1,166	63·10
111	30 to 34	6·60	9,358	1,419	65·10
Experimental Area—					
Pusa 20-1	12	0·83	1,058	1,275	63·88
20-1	16	1·43	1,976	1,382	64·04
3-1	15	1·12	2,103	1,878	65·50
3-1-1	13	0·36	746	2,072	65·04
163	13	0·37	828	2,238	63·86
113	13	0·07	156	2,226	63·72
115	13	0·33	297	900	58·74
52	14	1·13	1,728	1,529	65·30

4. STATEMENT SHOWING THE OUTTURN OF GRAM VARIETIES GROWN IN 1931-32

Crop	Plot No.	Area in acres	Outturn of grain in lb.	
			Actual	Per acre
General Area—				
Local	17, 18	4·09	3,737	914
Type 28	19	2·69	1,408	523
„ 58	20 to 23	9·69	8,128	839
„ 17	35 to 41	15·50	15,239	983
Experimental Area—				
Type 58	9	0·27	241	893
„ 28	9	0·27	243	900
„ 17	9	0·27	387	1,433
Local	9	0·27	186	689

5. STATEMENT SHOWING THE RESULTS OF OATS GROWN IN 1931-32

Crop	Plot No.	Area in acres	Outturn of grain in lb.	
			Actual	Per acre
General Area—				
B. S. 1	44 to 47	7·0	13,237	1,891
Hybrid A	43	0·6	810	1,350
B. S. 1	43	0·6	967	1,612
Hybrid B	43	0·6	570	950

6. STATEMENT SHOWING THE OUTTURN OF BARLEY GROWN IN 1931-32

Crop	Plot No.	Area in acres	Outturn of grain in lb.	
			Actual	Per acre
General Area—				
Type 21	48 to 50	4·18	5,211	1,246
„ 12	51	1·40	1,396	996

7. STATEMENT SHOWING THE OUTTURN OF LINSEED GROWN IN 1931-32

Crop	Plot No.	Area in acres	Outturn of grain in lb.	
			Actual	Per acre
Experimental Area—				
Type 12, unirrigated . .	1 part	0·7	328	469
„ 12, irrigated . . .	2	1·17	1,291	1,103
Hybrid 11	3	1·17	600	512
„ 10	4	1·17	564	482
Type 121	5, 6	2·32	1,773	764
„ 124	7, 8	2·30	1,679	730

REPORT OF THE SUGARCANE EXPERT

(Rao Bahadur T. S. Venkatraman, B.A.)

I. CHARGE AND STAFF

I held charge of the office of Sugarcane Expert during the year except for 45 days, during which leave period the Second Cane Breeding Officer, Mr. N. L. Dutt, held charge of the post in addition to his own duties.

The first crop of sugarcanes was planted during the year in the sub-station at Karnal.

II. SUGARCANE BREEDING (SUB-TROPICAL TYPES)

(*a*) Breeding Technique

A minor improvement in technique rendered it possible to employ, as mothers, varieties with fertile self-pollen. This was achieved by maintaining humid conditions round the mother arrows and thus preventing another dehiscence in these arrows till the artificially dusted foreign pollen got ample time to germinate and secured a clear start on any self-pollen that might fall on the stigmas later.

Seedlings raised with Co. 290 as mother have been known to be comparatively delicate, and in one of the bulk crosses of the year began to die off in larger numbers. Considerable improvement was noticed when the irrigation water was changed to one comparatively free from salts, but rich in organic matter. Quality of water was found to be of considerable importance in the germination of other delicate seedlings like those of intergeneric hybrids with cane.

(*b*) The Breeding Programme

The bulk crossing during the year was of Co. 290 × Co. 244 both of which had shown considerable usefulness under sub-tropical conditions. Besides the above, a large number of selfed seedlings were raised from Co. 312 and Co. 313, both recent seedlings of promise in the same areas. Crosses were also attempted between Co. 213 and Co. 221 (sugarcanes) and Sorghum, the latter being the pollinating parent.

(*c*) Sugarcane × Sorghum Hybrids

Out of 7,500 seedlings of P. O. J. 2725 × *Sorghum Durra* Stapf. grown during the year for a full year test, sixty were selected for further study. With the object of introducing greater vigour and hardiness into these hybrids, an appeal was published in the sugar

journals for seeds of sorghums—both wild and cultivated—possessing ample vegetative vigour. A collection of over 40 types was obtained, certain of the most interesting forms being those received from Kew. Four of these have been selected for use as parents in future hybridizations from a study of their shoot and root systems. A wild type, *Sorghum halepense*, was collected from the hills situate about 25 miles from the station for a similar purpose.

The more promising of these hybrids were planted at different times and under different conditions and analysed at intervals of a fortnight during the ripening period for cane at Coimbatore. Co. 352 would appear to be one of the most promising under Coimbatore conditions. It not only ripens in six to seven months, but also maintains its juice without appreciable deterioration for three succeeding months.

At the Sugarcane Research Station, Anakapalle, in the Madras Presidency, certain of the sorghum hybrids gave over 17 per cent. sucrose in juice at $6\frac{1}{2}$ months from sowing and fair quality *gur* (raw sugar) is reported to have been obtained.

Seven of these sorghum hybrids were distributed to nearly a dozen stations in sub-tropical India for testing. A second distribution of these hybrids was made in June to ascertain if, planted towards the beginning of the monsoon, they would ripen during the succeeding winter.

A set of carefully prepared herbarium specimens sent to the meeting of the International Society of Sugarcane Technologists at Porto Rico in March 1932 has received confirmation of the nature of these hybrids.

(*d*) Selection of Seedlings

Out of 350 new seedlings grown in the test plots, 32 were raised to the status of Co.'s for distribution. Their parentages are given elsewhere in this report. From periodical analyses, it was found that Co. 270 was one of the earliest to ripen, giving 17 per cent. sucrose in October. It was further found to maintain its juice practically at this level till January. Co. 284, Co. 296, Co. 313, Co. 347 and Co. 349 showed satisfactory juice qualities in these analyses.

For selecting useful types it was found advantageous to cut a whole row of each seedling, bundle the canes together and keep the bundles erect and in a line for studying their habit, straightness, uniformity and type of canes. A cane shredder was installed to facilitate the estimation of sugar and fibre in the seedlings selected for distribution.

(*e*) Distribution of Sugarcane Seed

Requests for seeds of sugarcanes (not cuttings) were received from many stations in sub-tropical India with the object of germinating and growing them under their conditions. An attempt was made to comply with such requests as far as possible. That

seeds could be germinated in sub-tropical India was established last year in the sub-station at Karnal and has been confirmed this year also. It is felt, however, that such growing from seed will need to be done on a mass scale for best results.

(*f*) Distribution of Selected Seedlings

Three hundred and fifty parcels of cane material consisting of 70 varieties, mostly Coimbatore seedlings, were forwarded to various places in India. The stations which had been specially financed by the Imperial Council of Agricultural Research for the testing of these seedlings received the largest number of them and fair quantities of each. Twenty-one foreign parcels were despatched to Hawaii, Africa and Leningrad.

III. OTHER INVESTIGATIONS

(*a*) Types of Saccharum spontaneum

The hybrids (2,000 in number) between P. O. J. 2725 as mother and different types of *Saccharum spontaneum* as father raised last season, were studied for their botanical, agricultural and chemical characters and interesting differences noticed. The juice quality of the hybrids differed according to the male parent. (Table I.)

Table I

Juice analysis of hybrids between P. O. J. 2725 and different types of Saccharum spontaneum (average of 50 seedlings)

Hybrids	Sucrose per cent.	Co-efficient of purity per cent.
P. O. J. 2725 × Java form	9·00	67·8
Saccharum spontaneum (Java)	4·23	43·4
P. O. J. 2725 × Dehra Dun form	11·98	76·0
Saccharum spontaneum (Dehra Dun)	4·30	48·7
P. O. J. 2725 × Coimbatore form	14·62	84·6
Saccharum spontaneum (Coimbatore)	8·47	69·6

It has been mentioned in previous reports that, whereas the Java form yields hybrids with comparatively less sucrose but more resistant to mosaic, the Coimbatore form gives seedlings with better juice quality but not so resistant to mosaic. It would appear that the employment of both the parents in future hybrids would be of considerable advantage.

FIG. 1.—New seedlings arranged for examination of 'habit' and 'type of cane' at the end of second year tests. Each bundle represents harvest of a row of ten clumps.

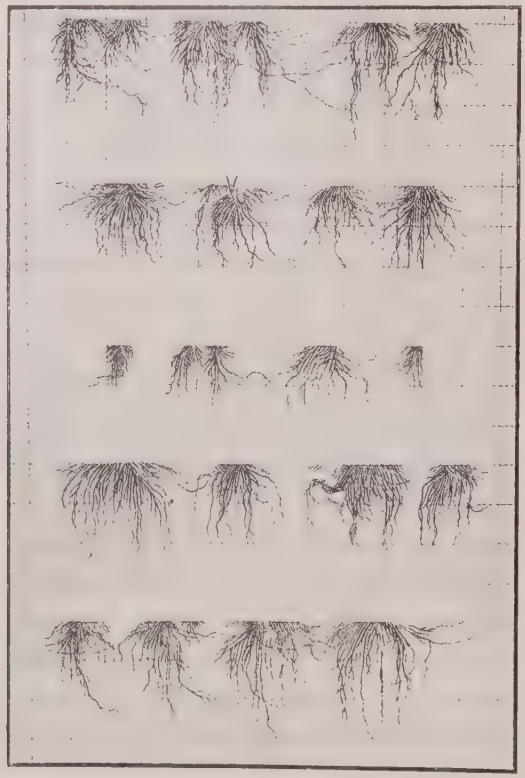


FIG. 2.—Root-systems of Co. 213 and its bud sports. From top to bottom the roots are of Co. 213, Striped Sport, Thin Yellow Sport, Thin Purple Sport and Thick Purple Sport.

One handicap at present is the fact that certain of the types, for example, the Lahore form, does not arrow under Coimbatore conditions. These have been planted under different conditions and are being grown continuously for the past three years to try and induce flowering in them.

(*b*) Bud Variations in Co. 213

The study of sporting in Co. 213 by Mr. R. Thomas referred to in the previous report was examined and written up for publication. The experience of sporting in this cane is similar to that recorded elsewhere with P. O. J. 36 and P. O. J. 213. One of the sports (Thin Yellow Sport) is obviously a degenerate type, while another (Thick Purple Sport) suggests the possibility of improving on this cane through bud selection (Plate II). A complete cycle of sports—striped and uni-coloured—has been obtained leading back to the original Co. 213. Table II gives certain of the important characteristics of these sports.

Table II

Certain characteristics of bud sports from Co. 213

	Weight per row of millable canes	Leaf length	Leaf width	Sucrose per cent. in juice	Co-efficient of purity per cent.
	lb.	Ft. In.	Inches		
Co. 213	91	4 7	2·1	17·48	88·5
Striped Sport . .	87	3 9	1·4	16·07	85·9
Thick Purple Sport . .	95	4 6	2·1	17·15	88·8
Thin Purple Sport . .	94	4 8	2·1	16·99	86·9
Thin Yellow Sport . .	3	3 0	1·1	12·09	77·0

Note.—The lengths and widths of leaves are the averages of one hundred measurements.

(*c*) Periodic Studies

The periodic studies of standard varieties and new sugarcane seedlings—including habit, tillering, shoot weights and shoot and root dissections—have indicated a comparatively simple method for testing and selecting canes to suit particular localities.

IV. PERFORMANCE OF COIMBATORE SEEDLINGS

Co. 299, Co. 301, Co. 312 and Co. 313 are certain of the promising seedlings from the recent batches. Co. 290 is getting increasing recognition almost everywhere. Co. 285 is definitely

establishing itself as superior to Co. 205, the previous cane of its class.

One rather interesting development during the year was the growth performance of medium canes like Co. 213, Co. 281 and Co. 290 in tropical India. At Anakapalle Co. 213 has been successfully grown with restricted irrigation and without the rather costly operation of wrapping and propping that has to be resorted to in the tract to prevent lodging during prevalent cyclones. Certain of these medium canes have spread to the northern parts of the Madras Presidency from Bihar. Even in a typical tropical part like Madras, it would appear that medium canes may have some use as a factor in lessening the cost of growing raw material and hence the cost of *gur*. It is well known that, in certain places, the high cost of *gur* is somewhat of an obstacle to the founding of modern sugar factories.

The area under Coimbatore canes in the whole of India is rapidly approaching a third of the total. The increased acre yields from these canes is leading to the establishment of additional white sugar factories in the sub-tropical cane belt. Fifteen such factories are expected to start working next season.

The Coimbatore canes are getting increasing recognition in foreign countries and certain of these were referred to in the previous report. In Queensland both Co. 281 and Co. 290 are reported " highly resistant to ' Gumming ' disease ". In Natal Co. 290 is proving " a vigorous grower nearly everywhere " and has shown " a high degree of immunity to both mosaic and streak disease ".

V. KARNAL SUB-STATION

(Financed by the Imperial Council of Agricultural Research)

Though the area at the station could be planted with the first crop of canes only in March 1932, a kind of preliminary work had been in progress at Karnal in previous years, through the kindness of the Imperial Dairy Expert and the Deputy Director of Agriculture, Hansi. The first batch of seedlings, grown from seed germinated at Karnal, was planted in the Provincial Agricultural Farm, and this work enabled the forming of preliminary ideas about the best time to sow cane seeds at Karnal.

The first crop at the sub-station was planted in March 1932 and consisted of about a hundred new seedlings bred at Coimbatore besides material from seed germinated at Karnal.

VI. RESEARCH AND INVESTIGATIONS BEARING MAINLY ON THICK CANE BREEDING

(N. L. Dutt, M.Sc.)

(*a*) Breeding

In the crosses made last year, satisfactory types of seedlings were obtained from those in which P. 608 and P. 519 were used as

parents. In the current season's hybridization programme, therefor, while retaining Vellai × P. O. J. 2878 as one of the bulk scale crosses, the above two seedlings were crossed with P. O. J. 2878 and Co. 364 respectively. Co. 364 itself was crossed with P. 858—a seedling of Kassoer—the object in this last combination being to secure mosaic-resistant seedlings. Besides the above, other small-scale experimental crosses were made to obtain information on the resultant type of seedlings.

About 180,000 seedlings were raised, out of which 55,000 were transplanted to the first ground nursery, and from these 14,000 vigorous seedlings were grown for the full year test.

(*b*) Selection of Seedlings

Chemical analysis was made of 557 vigorous seedlings from the final field plot and 248 were ultimately selected out of these and given P. numbers. Twenty other seedlings were selected out of those that were raised from the seed received from Hawaii. The seedlings raised from the seed received from Manjri were all of the thin type and were therefore rejected.

The promising P. seedlings that had been planted in different plots representing wet and garden land soil conditions were analysed with a view to selecting seedlings for distribution. These seedlings were analysed twice and 16 seedlings were finally raised to the status of Co.'s and were distributed to the various experiment stations in India. These seedlings are Co. 400 to Co. 415 and their parentages are given elsewhere in the report.

(*c*) Observations on Male Nuclei

The formation of the two male gametes before the shedding of the pollen was observed in some more sugarcane varieties, bringing the total number of varieties thus examined to 32. The presence of four male nuclei was observed in a few more varieties and seedlings, *viz.*, P. O. J. 1410, C. A. C. 87 and four P. seedlings whose male parent was B. 3412. Pluri-nuclear pollen grains have been observed by de Mol in *Hyacinthus orientalis*, and according to Nemec, who often observed triple fusion in the egg nucleus in *Gagea lutea*, the dispermatic fertilization leads to the origin of plants with triploid nuclei. In a microtome section of the cross Vellai × B. 3412, four male nuclei were observed inside the embryo sac. These observations on the four male nuclei in sugarcane are being continued to ascertain the significance of their occurrence.

(*d*) Cytological Studies

Considerable progress was made in the cytological studies that were taken up during the year. Flowers from canes in short blades were fixed in the following varieties for ascertaining the haploid chromosome numbers:—Vellai, Shamsara, Kaludai Boothan, Chittan, Poori, Fiji B., *Saccharum spontaneum* (Coimbatore type)

and Co. 205. The root tips of the above varieties as also of Pundia were fixed to ascertain the somatic number of chromosomes.

Though in certain pollen mother cells irregularities in meiosis were noticed, the haploid number of chromosomes in the majority of counts of Vellai, Shamsara and Poori was found to be 40. Meiosis was regular in *Saccharum spontaneum* (Coimbatore), and the haploid number of chromosomes was 32.

Co. 205 is a seedling of a cross between Vellai and *Saccharum spontaneum* (Coimbatore) and was found to have 56 chromosomes in the haploid phase. This is of interest, as it confirms Bremer's hypothesis that the hybrids of noble canes with *Saccharum spontaneum* have a somatic number equal to twice the noble chromosomes *plus* once the *spontaneum* chromosomes, that is, in this particular instance $2\ (40) + 32 = 112$.

In the cross Vellai × C. A. C. 87 an abnormal embryo sac was met with, in which the position of the components was found to be reversed, *i.e.*, the antipodals being towards the micropylar end, while the egg and polars towards the opposite end (Plate III, figure 3).

(*e*) Fertilization

The time taken by the pollen tube to reach the embryo sac was found to be seven hours in the cross P. O. J. 2725 × Co. 285 and $7\frac{1}{2}$ hours in Vellai × P. O. J. 1410 (Plate III, figure 1). The flowers of the above two crosses were fixed at definite intervals after pollination, and microtome sections were cut. In the cross Vellai × C. A. C. 87, however, the division of the primary endosperm nucleus was noticed to have begun eight hours after pollination, and the first division of the egg was seen to have been completed two days after pollination.

(*f*) Polyembryony

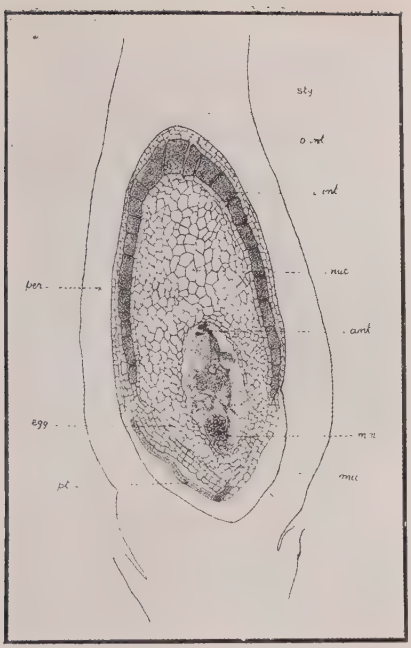
A case of more than one embryo was observed in the cross Vellai × C. A. C. 87 (Plate III, figure 2). The second embryo in this particular instance originated probably by the fusion of a male nucleus with a synergid, instead of with the polar nuclei. Polyembryony appears to be rare and non common in the sugarcane.

(*g*) Ovogenic Apogamy

Two cases of the development of the embryo from unfertilized eggs were noticed in the cross Vellai × C. A. C. 87. The absence of the traces of the pollen tube and the unfused nature of the polar nuclei lend support to the fact that fertilization has not taken place.

As many of the sugarcane varieties are probably of hybrid origin, the occurrence of the above phenomena is interesting, in view of Ernst's theory, according to which hybridization is the initial cause of polyembryony, apogamy, parthenogenesis and meiotic irregularity.

1



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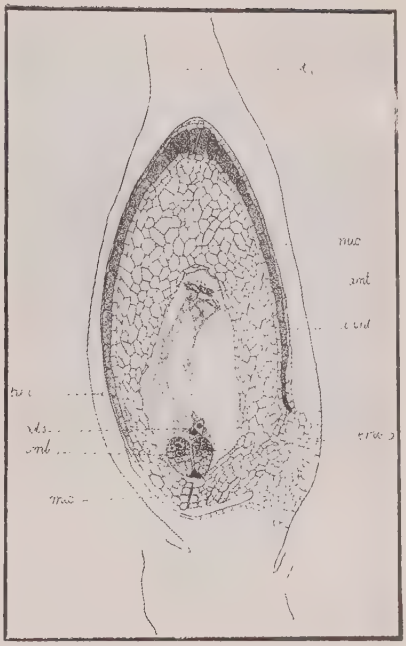

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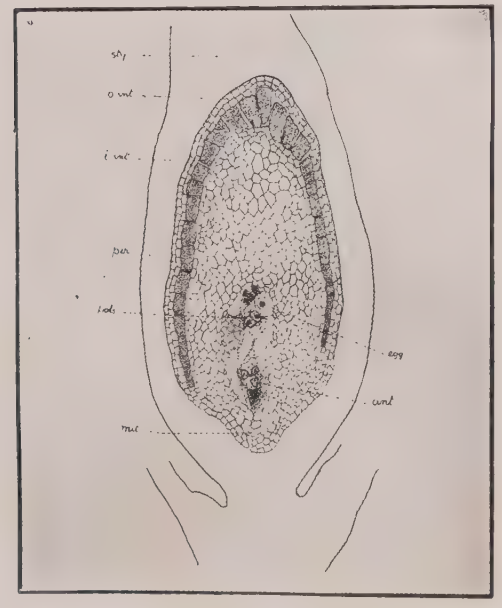

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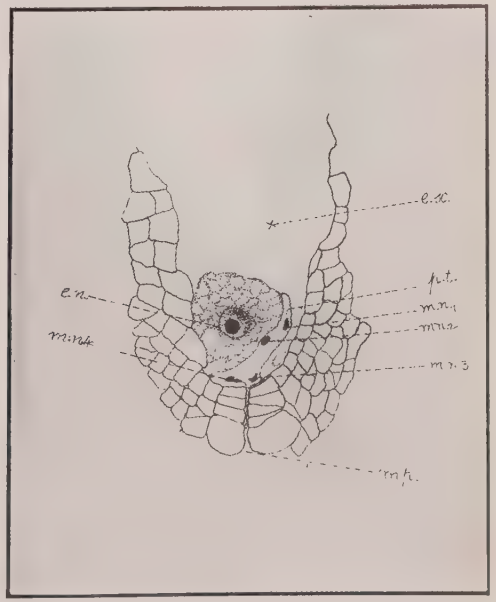

1. Vellai × P. O. J. 1410 shows the pollen-tube having reached the embryo-sac 7½ hours after pollination.
2. Vellai × C. A. C. 87 showing two embryos inside the embryo-sac.
3. Vellai × C. A. C. 87 showing an abnormal embryo-sac with the position of the components reversed.
4. Vellai × B. 3412 showing the pollen-tube inside the embryo-sac—with four male nuclei.

(*h*) Storage of Sugarcane Pollen

For maintaining certain relative humidities, the saturated solutions of lead nitrate, sodium bromate, potassium chromate, ammonium sulphate, etc., were used in place of the usual mixture of sulphuric acid and water in definite proportions. The above method was not found to be an improvement, and the pollen was therefore stored according to the method reported last year.

(*i*) Controlling time of Arrowing

(1) *By "topping"*. The experiments to control the time of flowering by "topping" the plants gave fairly satisfactory results. Flowering was delayed by twelve days and fifteen days in P. O. J. 2878 and P. O. J. 1410 which were topped thrice, *i.e.*, during the fourth, fifth and seventh month of growth; and by nine days in the varieties P. O. J. 2364, Kassoer and Co. 290 which were topped twice, *i.e.*, during the fourth and fifth month.

(2) *By subjecting to sub-normal day-length*. Seven months old plants of B. 6308 and P. O. J. 2725 were enclosed in a temporary zinc shed covered at top, the top being removed so as to subject the canes to six hours of daylight. The controls flowered at the normal time, but the experimental canes failed to flower. This was probably due to the fact that the canes were subjected to sub-normal illumination for three months. It is proposed during the next year to subject the canes for a lesser period.

(3) *By etiolation*. The variety P. O. J. 2725 was kept in the dark room three to thirteen weeks after planting. These canes together with the controls were planted in the field during November 1931, and the difference in flowering time, if any, will be noted during the next arrowing season.

(j) *Germination in thick cane seeds*. Germination counts were recorded in the seeds of certain important combinations, as also in the natural crosses of certain thick cane varieties. The germination in the following crosses was found to be better than in others: — Co. 364 × P. 858, P. 608 × Co. 364, Co. 365 × P. 701.

VII. PARENTAGE OF COIMBATORE SEEDLINGS

Parentages of seedlings raised to the status of Co.'s during the year are given in Table III.

Table III

Parentages of Co. canes

Seedling No.	Parentage
Medium Types—	
Co. 366	P. O. J. 213 × Co. 229.
Co. 367	P. O. J. 2690 × Co. 229.
Co. 368	P. O. J. 213 × Co. 214.

Seedling No.	Parentage
Co. 369	Co. 221 × P. O. J. 2696.
Co. 370	Co. 213 × Co. 214.
Co. 371	
Co. 372	
Co. 373	
Co. 374	
Co. 375	
Co. 376	
Co. 377	
Co. 378	Co. 281 × Co. 223.
Co. 379	
Co. 380	
Co. 381	Co. 214 selfed.
Co. 382	P. O. J. 2725 × Co. 243.
Co. 383	
Co. 384	Co. 213 × Co. 281.
Co. 385	
Co. 386	Co. 213 × Co. 214.
Co. 387	
Co. 388	
Co. 389	Co. 223 × Co. 281.
Co. 390	
Co. 391	Co. 221 × Co. 229.
Co. 392	Co. 221 × Co. 223.
Co. 393	Co. 243 × Co. 244.
Co. 394	
Co. 395	
Co. 396	Co. 214 selfed.
Co. 397	
THICK TYPES—	
Co. 400	Vellai × Q. 813.
Co. 401	
Co. 402	Vellai × Co. 243.
Co. 403	
Co. 404	Vellai × P. O. J. 2878.
Co. 405	B. 6308 × P. O. J. 2696.
Co. 406	B. 6308 × Co. 281.
Co. 407	P. O. J. 2725 × B. 3412.
Co. 408	P. O. J. 2725 × Co. 243.
Co. 409	P. O. J. 2725 × Fiji B.
Co. 410	P. O. J. 2727 G. C. (self or possible cross with D. 74).
Co. 411	P. O. J. 2727 × P. O. J. 2878.
Co. 412	P. O. J. 2878 × Co. 243.
Co. 413	Co. 290 × 247 B.
Co. 414	Co. 359 × Co. 360.
Co. 415	Maur. 1237 × P. O. J. 1410.

VIII. TRAINING OF STUDENTS

Mr. Siddique Ahmad Siddiqi, L. Ag., Assistant at the Shahjahanpur Research Station, underwent a short course of training at the station for about three months from the 4th December, 1931, to the 29th February 1932.

IX. MISCELLANEOUS

A set of herbarium specimens of arrows of sugarcane × sorghum hybrids was sent to Kew as desired.

Mr. S. L. Sen Gupta of the Department of Agriculture, Bengal, spent ten days acquainting himself with the work of the station. He is to be in immediate charge of a scheme of sugarcane research, including testing of Coimbatore canes, financed by the Imperial Council of Agricultural Research.

The visitors during the year included Drs. O. Posthumus and J. P. Bannier from Java, Dewan Bahadur Sir T. Vijayaraghavachariyar, Vice-Chairman, Imperial Council of Agricultural Research, Agricultural Expert to the above Council, Director, Imperial Institute of Agricultural Research, Pusa, Mr. Walchand Hirachand, Member, Sugar Committee, and the Directors of Agriculture and Industries, Madras.

X. PROGRAMME OF WORK FOR 1932-33

Major

The breeding of medium and thick canes will be carried on with the object of effecting further improvements or covering new tracts.

Intergeneric hybridization between sugarcane and sorghum as well as with other cereals will be continued to exploit fully the possibilities in this line of work.

Attempts will be made to improve the breeding technique further and secure better germinations from thick cane seeds.

Minor

Cytological studies for finding out the chromosome numbers of thick cane varieties, and fertilization and embryogeny in the thick canes.

Studies in sugarcane pollen and controlling time of arrowing.

Studies of the various forms of wild *Saccharums*.

XI. PUBLICATIONS

(1) Venkatraman, T. S. .	Sugarcane Breeding in Different Countries. (Sent to the Porto Rico Convention of the International Society of Sugarcane Technologists.)
(2) Venkatraman, T. S., and Thomas, R.	A Brief Note on the Sugarcane-Sorghum Hybrids. (Sent to the Porto Rico Convention of the International Society of Sugarcane Technologists.)
(3) Venkatraman, T. S. .	An Appeal for Seeds of Wild Sorghums. *Agriculture and Live-stock in India*, Vol. I, Pt. VI, November 1931.
(4) Dutt, N. L., and Krishnaswami, M.K.	Observations on Male Nuclei in the Sugarcane. *Indian Journal of Agricultural Science*, Vol. II, Pt. I, February 1932.
(5) Thomas, R. . .	Bud Variations in Co. 213. *Indian Journal of Agricultural Science*, Vol. II, Pt. 5, October 1932.

REPORT OF THE IMPERIAL AGRICULTURAL CHEMIST

(J. N. Mukerji, B.A., B.Sc.)

I. CHARGE

Dr. B. A. Keen held charge of the Section till the 14th November, 1931, when Dr. J. Sen, Plant Biological Chemist, took over charge, in addition to his own duties. Mr. J. N. Mukerji, First Assistant, took over charge on the 1st April 1932, when Dr. J. Sen proceeded on leave preparatory to retirement.

The Plant Biological Chemist's Section, as well as the post of the Physical Chemist, have been abolished with effect from the 1st April, 1932, as a measure of retrenchment.

II. EDUCATION

Mr. R. S. Chaturvedi, B.Sc., from the Indore State, who was admitted to the post-graduate course in November 1930, continued his studies.

III. METEOROLOGY AND DRAIN-GAUGES.

The usual meteorological records and records of drainage from four drain-gauges were maintained. In this connection sann-hemp and wheat crops from the gauges and 125 samples of drainage waters were examined.

IV. GENERAL ANALYTICAL WORK AND ASSISTANCE GIVEN TO OTHER SECTIONS

1. General Analytical Work

The following samples were analysed and reported upon:—

Soils	63
Manures	14
Feeding stuffs	3
Oilseeds	110
Sugarcane	294
Ghee	3
Milk	305
Waters	4
Chillies	15
Miscellaneous	2
Total	813

Thirty samples of soil were received from the Silviculturist, Forest Research Institute, Dehra Dun, for the purpose of ascertaining the effect of a leguminous cover crop of *Tephrosia candida* on the soil in respect of possible changes in total nitrogen content, humus and acidity that might be induced by it. The analytical data failed to show any significant difference between the *Tephrosia* and the non-*Tephrosia* areas. Five samples of soil were received from the Finance Minister, Rampur, in connection with the proposal to introduce sugarcane cultivation in certain areas within the State. The samples sent were of good quality so far as chemical composition is concerned. Of the samples of feeding stuffs examined, a sample of grass received from the Special Officer, Civil Veterinary Department, North Bihar, and reported to have caused several deaths among cattle, was found to contain 0·03 per cent. hydrocyanic acid.

A sample of air dried "Neel" (blue-green algæ with which the Sambhar Lake is infested) sent by the General Manager, Rajputana Salt Sources, Northern India Salt Revenue, was found to contain a high percentage of nitrogen and a fair proportion of phosphoric acid.

Analyses of two samples of water from the Indian Wood Product Co., Izatnagar, were carried out for the Deputy Director, Imperial Veterinary Serum Institute, Izatnagar. The samples contained a very moderate amount of total inorganic salts and, though rich in organic matter, were suitable for irrigation purposes.

At the request of the Deputy Director, Imperial Bureau of Soil Science, Harpenden, England, a comprehensive note containing an account of soil research in progress was supplied, in collaboration with the Imperial Agricultural Bacteriologist, for publication as a Monthly Letter of the Bureau.

2. Assistance rendered to other Sections

Agricultural Section. Nine samples of manures, 27 of soil, 214 of sugarcane in connection with the farm's variety test and manurial experiments, two of feeding stuffs, two of *ghee* and 305 of milk were analysed.

Milk of two leading cows and two lowest yielders in the herd is being examined twice every alternate day in order to see the variation in the fat content under special handling. These cows are milked four times daily with equal intervals between milkings and are kept on low concentrates.

Botanical Section. A hundred and ten samples of linseed and 15 of chillies were examined. The degree of pungency in 15 samples of chillies was determined by the bio-assay method of Munch, using a piperine solution of concentration 20 mg. per litre as standard. Besides these, a large number of soils taken from the areas under the Botanical Sub-station at Karnal were taken up for analysis. In this connection chemical analysis of 26 composite samples and mechanical analysis of 51 individual samples have been completed. The work is still in progress.

Mycological Section. Eighty samples of sugarcane from the mosaic tonnage plot were examined.

Entomological Section. "Topex cartridge", a rat-killer, was examined and found to contain mostly nitre and sulphur.

Power House, Pusa. A sample of engine oil was tested for its specific gravity and acidity.

Sugarcane Expert. Representative samples of soil were taken from the area under the Sugarcane Expert at Karnal last year. They have been examined chemically and mechanically. For chemical analysis 10 composite samples were made and for mechanical analysis 24 samples were selected out of 40 taken.

V. RESEARCH

1. Crops

Experiment on curing of tobacco. There are two general methods of harvesting the tobacco crop and arranging it in the curing shed. In one case the leaves are picked from the stalk as they ripen and are arranged on strings or sticks suitable for hanging in the curing shed. In the other method the leaves are not removed from the stalks, but the latter are cut off near the ground and suspended in an inverted manner in the curing shed. Of course, by this method all the leaves on the plant do not ripen at the same time, so that the tobacco is harvested at such time as will give the greatest number of the best leaves at the proper stage of ripeness. This necessitates a considerable sacrifice in both bottom and top leaves, since the former are over-ripe and the latter still immature, but the method saves labour.

During 1928, tobaccos for the curing experiment were cured with their stalks on, but owing to a prolonged humid weather during the time of curing, some of the tobaccos were attacked by mildews and spoilt. With a view to avoid the attack of mildews and also to ensure the harvesting of the leaves at the proper stage of ripeness, tobaccos for the curing experiment during two subsequent seasons were cured by picking the leaves from the stalk. This method is more expensive than the method of curing on the stalk, but possesses the great advantage that it is possible to harvest all the leaves just at the right stage of maturity. Although both methods are capable of giving good results, there may be differences in the character of the cured product as obtained in the two processes. On account of the water contained in the stalk, which gradually passes into the leaf to replace that lost by evaporation, the leaf under these conditions remains alive for a much longer period than when separated from the stalk. Since a portion of the reserve food supply of the leaf is transported into the stalk when it is left attached to the stalk, and since, further, the leaf remains alive for a longer period and so itself uses up more of its accumulated food, there is every probability of the leaves cured by this

method to be different in character from those cured after being separated from the stalk.

In order to ascertain this difference in character two lots of tobacco, each of Adcock and Pusa Type 28, were cured on racks by both these processes, and the cured products are being examined for their nicotine, sugar, starch, and amido and albuminoid nitrogen contents. These constituents have been recognized by several investigators to possess a direct bearing on the quality of tobacco, and attention is therefore confined to the examination of these for studying the differences in character. So far as the nicotine content is concerned (this being the only constituent which has been examined till now), tobaccos cured with their stalks on have invariably shown a higher nicotine content than those cured without stalk. This is evident from the table given below.

Description of tobacco	Cured on racks in sun protected from dew "with stalks on"	Cured on racks in sun protected from dew "without stalk"
	% Nicotine	% Nicotine
Adcock—early harvested . . .	2·82	2·13
Adcock—late harvested . . .	5·37	4·12
Pusa Type 28—early harvested . .	4·67	3·61
Pusa Type 28—late harvested . .	5·35	4·46

Potato storage experiments. Mr. P. B. Sanyal continued the experiment on the storage of potatoes during the year. Seed potatoes preserved till November 1931 were reduced to 34 per cent. of their original weight, whereas in 1930 the reduction was to 49 per cent. The atmospheric temperature in shade in 1931 was higher than that of 1930. The maximum in 1931 went up to 112°·3 F. as against 108°F. in 1930; it was over 110°F. for 9 days and over 105°F. for 18 days during 1931, whereas in 1930 it was over 105°F. for only 8 days. It had already been demonstrated in previous years that rot increases with the temperature, and the yield of preserved seed potato being much less during the year under report than last year further supports this fact.

From the experience of the last two years it may be stated that the most effective way of preserving potatoes from heat rot appears to be to store them in a dry cool place in heaps not more than 6 to 8 inches in height and to pick out occasionally the rotted tubers.

Attention was directed this year to the storage of the tubers in underground pits over sand of varying depths of 3, $2\frac{1}{2}$, 2 and $1\frac{1}{2}$ ft., and to compare them with those stored over sand on the ground and on bamboo shelf about 3 ft. high from the ground in a thatched house. Examination of daily records of

maximum and minimum temperatures at these different storing places shows the mean temperature of the underground cells to be 3·5° to 5·5° F. lower than those above ground and on the bamboo shelf. The tubers are as yet very little affected by heat rot and this method of storage so far appears to be successful.

Investigation of the cause of heat rot was carried out and the relation between the respiration of potatoes and the occurrence of "black-heart" in them was studied under more rigid conditions than last year. The tubers were confined in bottles containing air in volume six times that of the tubers and exposed to temperatures of 37°C. and 10° – 15°C. respectively. The respiratory ratio and the catalase activity of the tubers at different periods of incubation were measured and the occurrence of injury to the tissue known as "black-heart" closely observed.

The results of incubation of potato tubers at temperatures 37°C. and 10° – 15°C. have shown that in the case of the higher temperature the respiration was stimulated, and after four days' incubation the respiratory ratio (CO_2 evolved/oxygen absorbed) was unity; and thereafter the CO_2 evolution was far greater in comparison to the oxygen absorbed. At the lower temperature, the respiration was much less than that at 37°C., the respiratory ratio $\frac{(CO)_2 \text{ evolved})}{(O_2 \text{ absorbed})}$ reached unity after 7 days' incubation, and thereafter remained constant till the 23rd day, *i.e.*, till the period the experiment lasted. At temperature 37°C. the appearance of injury to the tissue known as "black-heart" occurred after four days' incubation, when catalase activity simultaneously decreased and practically stopped in about 12 days by which time the oxygen absorption by the tissue was reduced to nothing. At the lower temperature there was very little injury to the tissue even after 23 days and the catalase activity increased considerably for the first nine days and remained high till the end of the experiment.

Further experiments with potato tubers kept exposed to 10° – 15°C. for 25 days in the open, and then enclosed in bottles with six times their volumes of air, have shown that the respiration gets more accelerated in this case than when the tubers are not exposed to a low temperature previously.

The following conclusions emerge from the above experiments:—

(1) With the rise of the temperature the tissue respiration of the potato tubers is activated; (2) the supply of oxygen through diffusion into the tissues being inadequate to increased respiration at a high temperature, the tubers suffer from asphyxiation; (3) catalase which has the function of decomposing H_2O_2, which is regarded as a toxic substance produced as an intermediate product of respiration, disappears under anaerobic conditions and consequently injury to the tissue or "black-heart" occurs followed by the rotting of the tubers.

Food value of germinated grains. With a view to study the effect of germination on the composition and food value of crops, eight different kinds of seeds, *viz.*, gram, *mung*, barley, wheat,

paddy, maize, *juar* and *marua* were taken and allowed to germinate in the laboratory. When the radicles were about one and a half to twice the length of the grains and the plumules were just coming up, the plants were killed by cutting off the supply of moisture and exposing the seeds to sunshine (38°C.). The process was similar to that of commercial malting, the only difference being the higher temperature to which commercial malts are exposed at the final stage.

Having prepared the malts their composition was determined and diastatic activity estimated. A sample of malt (barley) was obtained from Solon Brewery and its diastatic activity was also determined for the sake of comparison.

The results demonstrated that, as is known, changes occur during the process of germination involving a dissolution of cell wall by enzyme cytase and the production of soluble carbohydrates, and there goes on hydrolysis of starch by diastase to dextrine and maltose and finally, if the process be allowed to continue, to glucose. The object of malting is to arrest germination at such a stage that very little glucose is formed and the chief products of hydrolysis of starch are dextrine and maltose in proportion suitable for the particular end in view.

On germination the radicles grow at the expense of a quantity of carbohydrates. The plumules also consume a large amount of carbohydrate during their development. Still a change is noted in the malt (from which radicles were removed) in the increase of its soluble carbohydrate content.

The albuminoids remain practically the same in amount; in some cases, however, there is a slight increase which may be ascribed to the lower moisture content of the malts, as compared to the unmalted grains.

The food unit values of the malts have been found to be somewhat greater than those of the unmalted grains, a result of the increase in soluble carbohydrates.

It was seen from the diastatic activity that barley malt prepared at the Pusa laboratory gave approximately the same result as the malt commercially prepared at Solon Brewery. Of the malts prepared the diastatic activity of the wheat products has been found to be the highest and that of the *mung* the lowest.

The malted foodstuffs produced above containing diastase and hydrolysed starch in the form of dextrine and maltose are thus more easily digestible. On account of this reason they may be used as invalid foods, the diastase, which is present, moreover serving to help the digestion of any other starchy foods.

Effect of manures on sugarcane juice. Earlier experiments have shown that the quality of sugarcane juice affects that of the *gur* to the production of which the major portion of the Indian cane crop is devoted. It has been shown in previous years that the application of nitrogenous manures increases the yield but lowers the quality of the juice, whereas sulphate of potash or superphosphate when applied alone generally improves the quality. Previous

experiments with combined manures have shown that a combination of superphosphate with potash and mustard cake produced better quality juice than one obtained by the use of mustard cake alone or in combination with either potash or superphosphate. As the experiment was planned in single plots, these results could not be taken as conclusive. The experiment is therefore repeated this year in quadruplicate plots, each of 1/40th acre. The manures have been applied in two doses, *viz.*, one-third at the time of planting and the rest at the time of earthing. Sugarcane variety Co. 213 is being grown in these plots.

Experiments on transpiration of sann-hemp and its decomposition in soil. It has been observed that sann-hemp crops used for the purpose of green-manuring do not break up completely even till February, specially in years when the monsoon fails. The sann-hemp seed is sown about the first week of June and the crop is ploughed in towards the end of July when the plants are six to seven weeks old. During this interval it removes a certain amount of water from the soil and in years of long continued drought and late monsoon it so happens that when the crop is ready to be ploughed in, there is hardly sufficient moisture in the land to break up the crop immediately. In order to find out the amount of water transpired by sann-hemp from germination to the time of ploughing in and also the amount of water evaporated from the soil surface during this period, pot experiments, in collaboration with the Imperial Agriculturist, have been started.

With a view to measure the rate of decomposition of sann-hemp crops with different concentrations of moisture in Pusa soil, and to find out if the addition of a small dose of sulphate of ammonia to sann-hemp helps the speedy decomposition of the stems and branches, a series of pot experiments have been started, in which sann-hemp alone and sann-hemp with sulphate of ammonia have been buried in down to about six inches depth. There are three series of pots; in the first moisture is being maintained at 8 per cent., in the second at 12 per cent. and in the third at 16 per cent. Sann-hemp plants of equal height and of equal thickness, and weighing 9 oz. in each case, have been added to each of the pots. The soil of these pots will be examined periodically for undecomposed twigs and stems, as well as for the products of decomposition.

2. Soils and Fertilizers

Alkali soil investigation. The physico-chemical examination of the alkali soils of Sakrand (Sind) from the *kalar* area, which was taken up last year, was continued. In this connection, examination of a typical soil profile of 42½″ depth (divided into 11 layers of depths varying from 3″ to 6″) from this region, started in June 1931, has been concluded.

It was reported last year, with regard to this particular area, that under natural conditions the soil is of the "solonetz" type. This is a term used in the modern system of soil classification for the result of a process that is characterised by two phases—(1) the

accumulation on the surface horizon of salts of alkali metals and (2) a subsequent base exchange, the calcium from the zeolitic humus complex being replaced by sodium with the formation of a sodium complex. The soil as a whole acquires a definite and recognizable structure and the exchanged calcium and other ions are washed down in solution to the lower layers, leading to the accumulation of gypsum in a layer of soil or "pan" perceptibly harder than the layers above or below. From the data obtained on the water extracts of Sakrand soil, this striking tendency of the monovalent ions to rise to the surface and the bivalent ions to leach downwards has been clearly exhibited. The existence of a hard gypsum layer was noted at a depth of $18\frac{1}{2}''$ to $24\frac{1}{2}''$.

A complete chemical analysis of the hydrochloric acid extract of the Sakrand soils shows that, of the trivalent cations iron and aluminum, the former behaves as a base and the latter as an acid aluminate. In an alkaline medium Fe_2O_3 is hardly affected by the leaching condition, hence the actual accumulation of this constituent between the depths 9" and $18\frac{1}{2}''$, in all probability, appears to be due to the leaching of the colloidal Fe_2O_3 from the surface soil through the stabilizing action of organic humus compounds. With the increased concentration of water-soluble salts, in the different horizons, more aluminates of Ca, Mg, K and Na pass into solution, whereas the colloidal Fe_2O_3 coagulates beyond a certain limit. Hence, in an alkali soil, like that of Sakrand, the sum of $Fe_2O_3 + Al_2O_3$ remains uniform over the whole profile. The presence of large quantities of calcium and magnesium points to the existence of both these bases as carbonates. The sum of these bases in the complex shows their leaching tendency from the surface soil. As reported before, there is an accumulation of the alkali bases in the complex in the surface soil.

As usual in an alkali soil, SiO_2 is mobile in this case too, thus giving rise to an accumulation zone between 15" and $24\frac{1}{2}''$, just below the leached layer 9" to 15". On the basis of this analysis it would be possible to distinguish four distinct horizons over which there is a characteristic distribution of the different bases and acids.

Determination of exchangeable bases of the Sakrand soils shows that (1) of the exchangeable bases calcium predominates over the other bases and determines the fluctuations of the saturation capacity with depth, (2) that chemical weathering has taken place more vigorously down to a depth of $24\frac{1}{2}$ inches as indicated by the high saturation capacity value, below which a hard pan layer exists —this is also indicated by the mechanical analysis, and that (3) the hard pan layer does not show any extraordinary degree of alkalisation and its formation may be due to the accumulation of gypsum, silica and heavy clay. The respective ratios of the monovalent to the bivalent ions, averaging as 0·36 (in a sweet calcareous soil it rarely exceeds 0·10), show that throughout the whole profile a considerable degree of alkalisation has taken place.

When the different proportions of bases brought into solution by (*a*) HCl, (*b*) electrodialysis and (*c*) water are compared it is

found that of the monovalent bases 45·9 per cent. is in the exchangeable form and 12·1 per cent. in the water-soluble form; among the bivalent bases only 18·8 per cent. is in the exchangeable form and 4·0 per cent. in the water-soluble form. Thus, in this type of saline soil, the monovalent bases, though only a fifth of the bivalent (17 : 83), yet exert a greater injurious influence than their actual amount indicates.

The apparent depression due to potash. Indications of the apparent ineffectiveness, or even depressing effect, of potassic fertilizers on yield have been found in several field experiments conducted at Pusa. Although the experimental design does not permit the degree of reliability to be estimated, the indication is brought out not only by the permanent manurial plots on the farm, but by the separate plot experiments conducted by this Section. The broad results are that whereas superphosphate, in combination with ammonium sulphate, gives marked increase in yield over the control, potash with ammonium sulphate gives distinctly inferior increase, little better in fact than with nitrogen alone; further, potash alone actually exerts a depressing effect, the yield being with rare exceptions below that of the control plots. The immediate practical importance is obvious; if the conclusion is confirmed by properly conducted field experiments it will not, in general, be necessary to use the relatively expensive potassic fertilizers for manurial purposes.

With a view to find out if the depression indicated in the field trials at Pusa with potassic fertilizers is due directly to potash, or due to some other indirect cause, such as the interaction of the sulphate of potash (the common and cheapest form in which this fertilizer is available and used) with the calcium carbonate present in the soil and thereby producing a condition unfavourable to the growth of plant, five small plots of equal area (each 250 sq. ft.) in duplicates have been laid out. Three of these plots, in duplicates, have been treated with potassium sulphate, potassium chloride and potassium carbonate respectively. The fourth one, in duplicates, has received calcium sulphate and the fifth one has been left untreated to serve as control. *Marua* (*Eleusine coracana*) has been sown in all these plots as a *kharif* crop and it will be followed by oats as a *rabi* crop.

Since the interaction of potassium sulphate with calcium carbonate gives rise to the formation of potassium carbonate and calcium sulphate, the latter has also been included in the experiment for the purpose of examining the independent action of this salt on the growth and yield of plants. Earlier experiments with gypsum (calcium sulphate) in Pusa soil have shown a depressing effect on the yield and if the present experiment further demonstrates this fact, the possible explanation of the apparent depressing effect of potash may be sought here. Moreover, potassium carbonate, another product of the interaction of potassium sulphate with calcium carbonate, may make the soil highly alkaline and thereby suppress nitrification and there is consequent depression on the yield.

Manurial effect of treated bones. A simple method for the preparation of bone fertilizers was reported last year. The method consists in disintegrating raw bones in a solution of alkali containing 1·5 per cent. caustic soda and 1 per cent. common salt. The bones are to be kept for about two months in contact with this solution in air-tight vessels. The ratio of bones to solution is recommended to be 1 : 4. After disintegrating a first lot of bones the used-up liquid can be used for at least two subsequent treatments with the addition of requisite amounts of caustic soda only. The cost of preparation of such alkali-treated bones is very low, being about half of what bonemeals or bone superphosphates cost; apart from the low cost of production, the alkali-treated bones have been found to be superior to both of them with respect to phosphoric acid content.

To test the fertilizing capacities of these alkali-disintegrated bones, it was considered worthwhile to compare them with bonemeal and bone superphosphates. Pot experiments with two types of soil, one a non-calcareous alluvium soil of Kalianpur near Cawnpur and the other an acid soil from Dacca, were therefore carried out, the crop grown being *marua*. The dimensions of bone fertilizers are of much significance on crop yields, and for the purpose of strict comparison fertilizers of the same grade were employed. In the case of bone superphosphate, which is fine and completely soluble in water, the stuff available in the market had, however, to be used. The pots were in triplicates and four plants were allowed to grow in each pot.

Flowering was not much influenced by phosphatic treatment in the case of Kalianpur soils, whereas in Dacca soils it responded to the fertilizer additions. In the Dacca soil, on the average there were only four flowers in the no-manure pot, six in the bonemeal pot, eight in the bone superphosphate pot, but with alkali-treated bones nine flowers were produced.

The following table gives the total yields of grain and stalks per pot.

Treatment	Kalianpur soil		Dacca soil	
	Mean weight of grains per pot in grm.	Mean weight of stalks per pot in grm.	Mean weight of grains per pot in grm.	Mean weight of stalks per pot in grm.
No manure	14·4	27·6	8·2	16·2
Bonemeal	14·4	21·8	15·2	22·2
Alkali-treated bones . .	16·3	24·8	19·1	24·2
Bone superphosphate . .	16·7	20·0	16·7	22·7

It is observed that the Kalianpur soil which contains a high percentage of total (0·073 per cent.) and of available (0·031 per cent.) phosphoric acid, responded little to additions of bone products, but that the Dacca soil being extremely poor in total (0·005 per cent.) and in available (0·0016 per cent.) phosphoric acid responded appreciably to them. The weight of both grains and stalks increased with the addition of phosphoric acid, and of the three bone fertilizers used alkali-treated bones prepared at Pusa produced best effects.

Relative utility of farmyard manure and sann-hemp to the soil with and without artificial fertilizers like superphosphate and sulphate of ammonia, with special reference to crop yields and biochemical changes. The object with which this work was taken up by Dr. B. K. Mukerji and Mr. S. Das was (1) to examine in detail whether the use of nitrogenous and phosphatic fertilizers would lead to an economic increase in the crop yields over those obtained by using indigenous fertilizers; (2) to follow closely the biochemical factors influencing nitrification in this country; (3) to study the underlying biochemical principles governing the decomposition of an indigenous green manure like sann-hemp in the soil with a view to making it an effective substitute for cowdung, which on account of its being used extensively as fuel is scarcely available for manurial purposes; and (4) to ascertain the limiting values of the different nutriments that are needed for a maximum crop yield. Accordingly, during the *kharif* and the *rabi* seasons of 1931-32, cropped and uncropped pot experiments were simultaneously carried out with an Indo-Gangetic alluvial soil obtained from Kalianpur. These pots were treated with farmyard manure, sann-hemp, superphosphate and sulphate of ammonia, either alone or in combinations, together with a basal dressing of K_2SO_4 at 20 lb. K_2O per acre in each case. In the case of both the nitrogenous and phosphatic manures, the rates of application of nitrogen and P_2O_5 were 20, 40 and 80 lb. per acre. Farm-yard manure and sann-hemp were also used in quantities to supply 40 lb. P_2O_5 per acre. *Marua* was grown in the *kharif* season and wheat as the following *rabi* crop.

Periodical examinations of soil samples drawn from the uncropped pots were made in the laboratory to study nitrogen changes and bacterial population. A similar set of experiments under the more controlled conditions of the laboratory were conducted to determine the effect of various manurial treatments on the soil bacterial population, nitrogen changes, and carbon-dioxide evolution, the last mentioned of which is taken as an index of soil fertility and is associated with the activities of soil micro-organisms.

The main conclusions emerging from the experimental data may be summarized as follows:—

(1) In the case of *marua*, sann-hemp in combination with super and Am_2SO_4 caused higher yields than farmyard manure in similar combination. With wheat, however, a reverse effect was obtained.

Marua was found to respond to both nitrogen and phosphate, while wheat to phosphate alone in the present instance.

The limiting values of phosphate and mineral nitrogen causing an increased yield of wheat are respectively 60 and 100 lb. per acre. When the nitrogen supply exceeds this limit, there is a marked decrease in yield. A similar, but less pronounced, effect is also noticeable with regard to phosphate.

With *marua*, however, no such characteristic limit is evident; there is a more or less concomitant increase in yield when nitrogen and phosphate are gradually increased from 20 and 40 lb. respectively to 160 and 100 lb. per acre.

(2) From the course of CO_2 evolution and nitrate formation sann-hemp appears to decompose faster than farmyard manure. The course of nitrification of soils under various manurial treatments remains the same during the *kharif* and the *rabi* seasons, although it is somewhat slower during the latter owing perhaps to the prevailing lower temperature.

(3) In the case of *marua* there seems to be a direct relationship between yield and nitrate formation. No such relationship, however, exists in the case of wheat, due perhaps to its non-response to a higher dose of nitrogen than 100 lb. per acre.

(4) The bacterial number increases in all treatments containing sann-hemp alone or in combination with artificials. With Am_2SO_4, however, it is observed to decrease with the increase in dose. Super has a markedly stimulating effect, whereas farmyard manure, contrary to expectations, exerts a somewhat toxic effect on it.

In treatments containing sann-hemp or Am_2SO_4 there is approximately an inverse relationship between bacterial number and nitrate formation. With super and farmyard manure, however, such relationship tends to be direct.

(5) Both CO_2 evolution and bacterial number increase markedly in soils supplied with sann-hemp, but excepting the first few days no simple relationship is apparent between them. Am_2SO_4 at a lower dose causes a slight increase in CO_2 production, but at 80 lb. nitrogen per acre depresses it. Super alone greatly stimulates it, whereas farmyard manure alone does not increase it, but, when combined with super and Am_2SO_4, caused a marked rise. Unlike sann-hemp, there is a direct relationship between CO_2 production and bacterial number in the case of farmyard manure.

The efficiency (carbon dioxide produced per bacterium) of the organisms in these treatments decreases with the increase in their population.

There is a co-relationship between carbon dioxide evolution and total yield (grain + straw).

(6) It is interesting to note that during the two cropping seasons under study only a fraction of the nitrogen added to the soil in the form of sann-hemp or farmyard manure was converted into nitrate.

For instance, 45 to 70 per cent. nitrogen of sann-hemp and only about 40 per cent. nitrogen of the farmyard manure was nitrified.

A paper dealing with the results obtained is in course of preparation.

Nitrifiability and manurial value of apricot seed cake. Wild apricot trees grow abundantly on an extensive area in Simla Hills. Their fruits are locally consumed and the oil from seeds is used for cooking, burning, and as an hair-oil. The cake left after extracting oil is neither utilized as a cattle food owing to its bitter taste, nor does it find an application as a manure in the locality, notwithstanding the fact that it contains considerable proportions of nitrogen, phosphoric acid and potash. It is used there as a fuel, entailing an economic loss. As the cake, however, appears to possess a high manurial value, especially with regard to its nitrogen-content, *viz.*, 6·7 per cent., its nitrogen changes in a non-calcareous Kalianpur soil having less than 1 per cent. lime and a highly calcareous Pusa soil having 35 to 40 per cent. of calcium carbonate are being investigated from the biochemical point of view. Promising results have emerged so far from this study. In seven to eight weeks' time 63 per cent. nitrogen of the cake is transformed into available forms in both the soils and then maintained at this concentration till the fourteenth week's incubation. But the manner in which this change takes place in the two soils under study is peculiar as will be evident from the following facts.

There is an abundant formation of ammonia in the Pusa soil, which goes on increasing till it reaches the maximum in about three weeks' incubation. Then it rapidly decreases during the next five weeks, after which it slackens, remaining practically constant till the 14th week's incubation, when the soil still contains 4 mg. of nitrogen as ammonia. The nitrate formation rather lags behind the control during the first $3\frac{1}{2}$ weeks, after which it rapidly rises, reaching the maximum in eight weeks followed by a concomitant fall of ammonia, and later on it remains practically constant till the 14th week's incubation.

On the other hand, in the case of Kalianpur soil the accumulation of ammonia is considerably less throughout. In the first week there is a sharp increase of ammonia followed by a steep fall in the next week, and then the curve of ammonia formation slopes down, running slightly above but parallel to that of the control. The nitrate formation, initially lagging behind the control during the first week, rises rapidly during the next $3\frac{1}{2}$ weeks. Then it slackens reaching the maximum in seven weeks and thereafter remaining practically constant till the 14th week's incubation.

The probable causes of this peculiar behaviour of the cake in the above two soils are being investigated, and its nitrogen changes will be studied in a sample of soil from Solon in Simla Hills, where the cake is likely to be more conveniently used as a manure.

Lime requirement of acid soils. Mr. S. Das continued the investigation on the lime requirement of acid soils during the year.

One of the probable causes that interfere with the agreement between different lime requirement methods is that soils containing varying amounts of soluble salts and replaceable bases may exert a differential effect on the successful application of these methods. In order to eliminate this disturbing factor and ascertain its range of influence on the methods some soils were exhaustively treated with dilute acid in the cold to remove all salts and replaceable bases and then washed free from acid with water. After drying, these desaturated soils were tested with some well-known lime requirement methods with the following results.

The application of lime requirement methods to desaturated soils

Method tested	Lime requirement per 10g. soil expressed as c.c. 0·1N alkali				
	Akola soil	Bangalore soil	Godavari soil	Shillong soil	Dharwar soil
Hopkins	33·75	2·00	10·70	6·50	27·50
Loew	20·00	2·90	12·00	8·40	18·90
Kappen; also Daikuhara .	33·85	2·10	10·30	6·25	26·75
Do. with calcium acetate.	38·70	4·10	16·40	15·50	33·80
Do. with sodium acetate.	37·40	3·25	14·90	14·90	32·10
Jones	38·90	3·60	14·30	12·20	30·55
Truog	50·00	13·20	9·70	13·40	10·10
Lyon and Bizzell . .	72·40	8·20	28·40	39·60	60·10
Tacke	59·00	13·40	24·80	20·60	42·40
Hutchinson and MacLennan	44·00	3·75	17·50	17·00	35·00
Veitch	47·20	..	..	..	..

The elimination of soluble salts and replaceable bases appears to have minimised the effect of the disturbing factor to a certain extent, but still the agreement between the methods is far from satisfactory except in a few cases only.

In order to obtain further confirmatory data, four acid soils were desaturated by leaching them with dilute hydrochloric acid, and the hydrogen soils thus formed were washed free from acid with water and dried. The pH of these hydrogen soils was measured by the quinhydrone electrode and their titration curves were drawn by titrating them with 0·04 N lime water. On the basis of this observation a few soil mixtures having definite pH

values were prepared by intimately incorporating proportionate amounts of lime water to the hydrogen soils and drying them slowly with occasional stirring.

A few well-known lime requirement methods were tested on these soil mixtures with the result that no agreement was found between the calculated and the experimental residual lime requirement values, thus confirming the inadequacy of the existing methods as a quantitative measure of lime requirement of acid soils.

For the amelioration of acid soil conditions from the farmer's point of view and in order to obtain correlative data for laboratory studies pot experiments are now being instituted with an acid soil from the Jorhat Government Farm, Assam, by adding 1/3, 2/3, 3/3, and 4/3 of the lime required to bring the pH of the soil to 7. The lime required will be calculated on the basis of the buffering power of the soil as determined by the method of Jensen-Christensen.

Periodical examination of soil samples drawn from pots will be made in the laboratory. There will be cropped and uncropped experiments side by side, and the experimental plots will have a basal dressing of N, P, and K as used in ordinary farm practice.

VI. RESEARCH PROGRAMME FOR 1932-33

1. *Study of the soils of tobacco tracts in India.* Soils of various tracts in India where tobacco is extensively cultivated differ very widely from one another both in physical and chemical characters. These soils are either black heavy (*regur*), red laterite, sandy, or fine silty (alluvial). Some of these are of acidic character and some alkaline. Attention will be confined to the examination of soils of different tobacco-growing tracts in India with the object of finding out common factors which influence the growth and yield of this crop.

2. *Nitrogen balance in Indian soils.* The analytical data from the permanent manurial plots will be completed and examined for the purpose of constructing a nitrogen balance-sheet for the different systems of manuring.

3. *Lime requirement of acid soils.* Earlier work has confirmed the inadequacy of the existing laboratory methods as a quantitative measure of lime requirement of acid soils. For the amelioration of acid soil conditions and in order to obtain correlative data for laboratory studies, pot experiments will be carried out with an acid soil by adding increasing aliquot portions of the lime required to bring the pH of the soil to 7. There will be cropped and uncropped experiments side by side, and periodical examination of soil samples drawn from uncropped pots will be made in the laboratory.

4. *Decomposition of sann-hemp in soils.* The soils of pots treated with sann-hemp alone or in combination with sulphate of ammonia in all the three series of pots having 8, 12 and 16 per

cent. moisture, will be examined periodically for undecomposed twigs and stems, for nitrate formation and carbon dioxide production, with a view to find out the progress and the rate of decomposition with different concentrations of moisture.

5. *Nitrifiability and manurial value of apricot seed cake in soils.* Attention will be concentrated on the close examination of the nitrogen changes of the cake in a few types of soil from the biochemical points of view, and also the determination of its manurial value, with special reference to its nitrogen supply, by pot or field experiments.

6. *Effect of potash on the yield of crops.* The effect of potassic fertilizers on the *kharif* and *rabi* crops in small field experiments will be noted, and the soils, after each harvest, will be examined for any change in the manurial constituents and the pH value.

7. *Effect of manures on sugarcane juice.* The quality of sugarcane grown in Latin Square plots treated with mustard cake alone, and in combination with sulphate of potash, or superphosphate or both, will be periodically tested from November to the harvest time. From an examination of the quality and the yield of the crop, the most suitable combinations of manure will be found out.

8. *Storage of potatoes.* Storage of potatoes in underground cells minimised rotting but the stored tubers sprouted three weeks earlier owing to humid atmosphere in the cell. In the ensuing year, therefore, the effect of early sprouting of seed potato on the yield of the crop will be examined, and storage under drier conditions in cemented underground cells in the presence of suitable desiccating agents will be tried. Laboratory experiments to find out whether the beginning of heat rot in potatoes is due to bacterial or enzymatic action, will be carried out.

VII. PUBLICATIONS

Das, S. . . . . The Effect of Gypsum on Calcareous Soils. Accepted for publication in *Agri. and Live-stock in India.*

Hossain, M. A. . . Disintegration of Bones by Alkali method and their use as Fertilizers. Accepted for publication in *Agri. and Live-stock in India.*

REPORT OF THE PHYSIOLOGICAL CHEMIST

(A. Viswanatha Iyer, B.A.)

I. CHARGE

The Section was under the charge of Mr. F. J. Warth till the 4th April, 1932, and then I held charge.

II. LABORATORY WORK

The following is a list of analyses completed during the year:—

Complete analyses:—		
1. Fodders	46	
2. Fæces	72	
	—	118
Dry matter in fæces, urine, fodders, etc. . .		2,612
Single nitrogen determinations in fresh fæces, fodders, urine, etc.		744
Mineral analyses of urine, fodders, fæces, etc. . .		195
Partial mineral analyses		192
Complete analyses of urine		255
Miscellaneous analyses		323
Total .		4,439

III. RESEARCH AND INVESTIGATION WORK

1. Experiments on Nutrition of Growing Animals

An experiment on mineral feeding to growing animals is in progress. The fodder employed is a typical mature hay which is known from our previous tests to be somewhat deficient in minerals.

2. Experiments on Milk Production

Last year an interesting experiment was reported in which it was shown that the amount of silage could be materially reduced without causing a loss in milk yield. The test has been repeated this year and the previous result confirmed. The figures in last year's report may therefore be accepted as reliable and worth careful consideration by dairymen. The original experiment is fully described in *Agriculture and Live-stock*, Vol. II, Part 1, page 13. A new experiment has been commenced to determine the influence of high and low protein feeding. This work is being carried out in co-operation with the Imperial Dairy Expert.

3. Indian Coarse Fodders

Digestion experiments have been carried out with the following typical fodders during the past year. Of these, Aurangabad hay is noteworthy in having yielded an exceptionally acid urine which turned litmus paper bright red. This fodder was found to cause purging at times. A scented grass, which is generally not relished, was eaten by our bullocks after some hesitation, when it had been converted into hay. From the figures given below, it could be seen that this is a very rich fodder and the animals, if they could be persuaded to eat it, could thrive better on it than on any of the other samples. The figures also show the effect of maturity on the digestibility of the several ingredients in a fodder, the digestibility decreasing as maturity advances, which is very marked in the case of protein.

Percentage digestibility of some typical fodders

Description of sample	Organic matter	Protein	Fibre	Total carbohydrates
Bolarum hay (2 tests)	53·5	11·3	59·2	55·4
Tornagallu hay (2 tests)	51·3	..	57·5	53·2
*Aurangabad hay (2 tests)	51·8	4·0 / 21·6 } 12·8	57·4	53·3
Boda hay (1 test)	44·1	13·8	50·8	45·4
Scented grass hay (1 test)	56·2	46·7	63·8	57·8
Meerut hay—1st cut	54·5	28·0	54·3	56·1
Do. 2nd cut	52·1	13·5	53·5	54·2
Do. 3rd cut	50·6	9·5	50·5	52·5
Jubbulpore hay—1st cut	58·0	22·7	63·8	60·1
Do. 2nd cut	56·7	12·4	63·2	59·1
Do. 3rd cut	51·9	..	58·7	54·4

* This hay produced a strongly acid urine. Protein digestibility varied widely, hence the figures are given separately.

4. Mineral Requirements

An experiment on mineral feeding to bullocks has yielded some interesting information. The experiment was a comparative test with the two fodders, *ragi* (*Eleusine coracana*) straw and mature hay. The feeding test was divided into the three following main periods:—

1st period—The fodder without mineral supplement.

2nd period—Fodder with supplement of calcium phosphate.

3rd period—Fodder with supplement of calcium phosphate and green food.

The last test was intended to determine whether green food with its accompanying vitamins led to further assimilation. During each period numerous determinations of the mineral balance were made. The following statment shows the average results obtained for each period:—

	Ragi straw		Hay	
	CaO	P_2O_5	CaO	P_2O_5
1st period	+2·38	+0·09	—0·08	—3·16
2nd period	+11·57	+4·31	+5·90	+6·30
3rd period	+3·42	+1·08	+7·42	+6·21

With regard to *ragi* straw it may be concluded that this fodder is well provided with lime as appreciable assimilation took place in the first period. The P_2O_5 seems to be on the border line of sufficiency. The animals on this ration were evidently not suffering from lime shortage yet in the second period there is a further very large assimilation of lime. This is an important result, probably indicating the influence of phosphate on lime assimilation.

With regard to the hay ration, the experiments show that this fodder is undoubtedly deficient in phosphate. It is interesting to note that lime assimilation with this ration continues throughout the second and third periods. Again there is an indication that phosphoric acid influences lime assimilation.

Further experiments on the same lines have been undertaken together with tests on growing animals. These experiments are in the preliminary stage at present.

5. Silage Investigations

The study of silage making from sorghum has been brought to a conclusion. A paper dealing with the effect of the stage of

maturity on ensilage has been sent for publication. Briefly the experiments show that:

(1) The prime stage produces the best silage with the least losses.

(2) It is more profitable to ensile the straw rather than use it in the raw state.

(3) The immature plant is quite unsuitable for ensilage.

The following figures relating to changes undergone by protein during ensilage are instructive:—

	Average percentage gain or loss during ensilage		
	Crude protein	True protein	Amides
Immature stage	—6·4	—44·2	+88·0
Prime „	—2·4	—28·4	+77·1
Straw „	—5·4	—12·7	+18·4

It is seen that the loss of true protein is greatest in the immature plant and least in the straw. The gain in amides corresponds to the loss of true protein. The next table shows the changes undergone by organic acids, volatile bases and amino acids.

	Organic acids				Volatile bases		Amino acids	
	Volatile		Non-volatile					
	Fresh sorghum	Silage	Fresh sorghum	Silage	Fresh sorghum	Silage	Fresh sorghum	Silage
Immature sorghum	2·67	7·26	..	..	0·12	6·10	2·86	0·99
Prime .	1·60	4·67	0·51	3·55	0·24	1·26	1·58	2·13
Straw .	0·24	4·06	..	1·70	0·12	0·35	1·06	0·78

NOTE.—All expressed in grm. per 100 grm. dry matter.

The unsuitability of the immature plant for ensilage is emphasized by the absence of non-volatile organic acids, the large increase in volatile bases and volatile acids, as well as of the destruction of amino acids in the silage. This is a most convincing catalogue of unfavourable changes accompanying the ensilage of immature sorghum.

6. Physiological Studies

(a) *Detoxication of benzoic acid.* This work has been in progress during the past three years and has yielded the following information:—

(1) Benzoic acid is produced quantitatively from food-stuffs by the animal. Some fodders produce twice as much as others. Proof of quantitative production rests upon the fact that different animals give similar results with the same fodder. The following figures illustrate this point:—

Benzoic acid excretion per 100 grm. fodder consumed

Fodders	Animal	Benzoic acid per 100 roughage consumed
Ragi straw	R	0·755
	V	0·785
	A	0·764
Sorghum straw . . .	L	1·093
	N	1·035
	K	1 029
Bolarum hay . . .	N	1·517
	K	1·374
	A	1·486

(2) With Indian cattle there is only one form of conjugation, namely, that producing hippuric acid, a compound of benzoic acid with glycine.

Conjugation of benzoic acid by cattle

	Ragi straw		Bolarum hay	
	L	K	R	A
Total benzoic acid per 100 c.c..	52·6	49·3	121·3	63·9
Glycine per 100 c.c. . .	50·4	46·8	119·4	62·4
	2·2	2·5	1·9	1·5
Nitrogen balance . . .	+3·4	+3·9	+1·81	—2·07

(3) Hippuric acid production exerts a definite adverse influence on the nitrogen balance. This fact has been established by full tests from which the evidence is conclusive. The following tabular statement makes it clear that under parallel conditions urinary excretion of nitrogen is greater when hippuric acid excretion is higher.

Relation between nitrogen excretion and hippuric acid nitrogen

Ragi straw			Bolarum hay		
Animals	Nitrogen in urine	Nitrogen as hippuric acid	Animals	Nitrogen in urine	Nitrogen as hippuric acid
1	21·28	5·50	5	22·08	6·93
2	19·86	5·09	6	24·43	6·46
3	19·78	4·77	7	21·01	6·24
4	18·80	4·21	8	21·32	5·57

This is a matter of practical importance in India where cattle are so often reared on little or no concentrate and with a bare margin of nitrogenous food.

(b) *Sulphur metabolism.* Following up the observation of Aitken, it has been found that a large proportion of the sulphur in common fodders exists as inorganic sulphate. In concentrates this is not the case. Metabolism experiments with bullocks have established the two following facts:—

(1) The sulphur of concentrates does not appear in the urine unless it is fed in large excess.

(2) There is evidence to show that some inorganic sulphate is assimilated.

It should be repeated here that the importance of this work on sulphur lies in the fact that many typical crops have shown a distinct deficiency in sulphur.

(c) *Acid-base balance.* A continuation of this work has led to the important observation that lime is very decidedly deflected into the urine from the fæces when there is a tendency to acidity of urine as may be seen from the following table

CaO in urine and fæces (Percentage distribution)

Experiment No.	Ragi straw		*Bolarum hay	
	CaO in		CaO in	
	Urine	Fæces	Urine	Fæces
1	1·62	98·38	7·89	92·11
2	1·20	98·80	10·47	89·53
3	3·07	96·93	9·95	90·05
4	2·77	97·23	10·85	89·15
5	2·49	97·51	9·64	90·36
6	0·70	99·30	12·41	87·59
7	1·46	98·54	.	..
Average	1·90	98·10	10·20	89·80

* This hay produced acid urine.

Intestinal disorder has repeatedly been noted in such cases. This seems to be an important result obtained from our urine work.

(d) *Digestion of fats.* Preliminary experiments have shown that the unsaturated fatty acids are more completely digested than the saturated fatty acids. The unsaponifiable matter is not digested to an appreciable extent. In this case results vary with the nature of the fodder. The following table illustrates these facts:—

Fodders	Digestibility per cent. of		
	Unsaponifiable matter	Unsaturated fatty acids	Saturated fatty acids
Ragi straw ration	..	94·2	75·1
Hay ration	40·2	91·5	71·7

IV. CO-OPERATION WITH OTHER DEPARTMENTS

(1) *Military Farms Department.* Many samples of hay were received from the military farms for the determination of their feeding values. Digestion experiments have been carried out and the results will be published in due course.

(2) In the work on pasture grasses, the Section is receiving help from Pusa, and also from the Madras, Bombay, Bengal and Bihar and Orissa Departments of Agriculture.

It should be mentioned here that the Madras and Mysore Departments of Agriculture have given very generous help to the Nutrition Section in various ways, particularly in lending us animals which we were not in a position to procure.

V. PUBLICATIONS

The following papers were published during the year under report:—

1. Silage investigations at Bangalore: II—Quality and yield of silage in relation to filling conditions, by T. S. Krishnan. *Indian Journal of Veterinary Science and Animal Husbandry*, Vol. I, Part IV, December 1931.
2. Experiments on rationing of silage to cows, by the Post-graduate Students. *Agriculture and Live-stock in India*, Vol. II, Part I, January 1932.
3. A feeding experiment to compare the merits of single and mixed fodders, by the Post-graduate Students. *Agriculture and Live-stock in India*, Vol. II, Part 1, January 1932.

The following papers have been submitted for publication:—

1. Silage investigations at Bangalore: III—Effect of the stage of maturity on the ensilage of *juar*, by T. S. Krishnan.
2. The influence of urinary reaction on excretion of lime and magnesia, by N. Krishna Ayyar.
3. Silage investigations at Bangalore: IV—Ensilage of *juar* straw, by T. S. Krishnan.
4. An experiment on mineral assimilation from two typical fodders, by F. J. Warth, A. V. Iyer, and N. Krishna Ayyar.
5. A preliminary experiment on the digestion of fats by bullocks, by P. A. Seshan.
6. The quantitative production of benzoic acid and phenols in the animal system, by F. J. Warth and N. C. Das Gupta.
7. The conjugation of benzoic acid by Indian cattle, by N. C. Das Gupta.

8. An experiment to determine the effect of hippuric acid excretion on the nitrogen balance, by F. J. Warth and N. C. Das Gupta.

9. High versus low silage feeding for milch cows, by the Post-graduate Students.

10. Sulphur and sulphate balance experiments with cattle, by F. J. Warth.

11. A new method for the iodometric titration of phenols, by F. J. Warth.

VI. PROGRAMME OF WORK FOR 1932-33

Major subjects

1. Experiments on the nutrition of growing animals.

2. Experiments on milk production, a continuation of the work reported this year.

3. A study of Indian coarse fodders, including determinations of maintenance rations and studies of nitrogen and mineral metabolism. This is a continuation of the systematic work already reported.

4. Indian pasture grasses, the special enquiry described in last year's report.

5. Silage experiments.

6. Physiological studies.

Minor subjects

1. A study of the chemical methods employed in the above enquiries.

2. Preliminary experiments for the initiation of work on other aspects of nutrition.

REPORT OF THE IMPERIAL MYCOLOGIST

(W. McRae, M.A., D.Sc., F.L.S.)

I. CHARGE

Dr. W. McRae was appointed Director from the 14th November, 1931, in addition to his own duties as Imperial Mycologist. On Dr. McRae's appointment to officiate as Agricultural Expert to the Imperial Council of Agricultural Research from the 13th June, 1932, he handed over charge of the Section to Dr. M. Mitra. A new post in Class II service was created to which Dr. B. B. Mundkur was appointed with effect from the 11th September, 1931, and the post of Second Imperial Mycologist and a post of Assistant were retrenched.

The scheme for research on mosaic and other diseases of sugarcane financed by the Imperial Council of Agricultural Research was started from the 1st June, 1932, and Dr. S. V. Desai, Assistant to the Imperial Agricultural Bacteriologist, was appointed Sugarcane Mycologist. The laboratory for this work is being fitted up and the staff recruited.

II. TRAINING

Mr. U. B. Singh, M.Sc., completed his post-graduate training on the 31st October, 1931, and continued his studies as an honarary research worker. Two students from the Imperial Institute of Animal Husbandry and Dairying, Bangalore, received a short course on diseases of fodder crops during March, 1932. Mr. Akshaibar Lal, M.Sc., of the Department of Agricultural Botany, Benares Hindu University, worked in the laboratory from the 18th May, 1932, on systematic mycology. Dr. H. Choudhuri, Reader in Botany, Punjab University, visited the laboratory and help was rendered to him in identifying some of the citrus disease organisms occurring in the Punjab.

III. DISEASES OF PLANTS

(*i*) Pigeon-pea

Fusarium vasinfectum on *Cajanus indicus*. In collaboration with the Imperial Economic Botanist, the investigation on the isolation of a wilt-resistant type of *rahar* was continued and completed.

During the year the resistant capacity of Type 80, which in former reports was mentioned as Type A_2, was again put to the test. In one of the triangular portions of Bara 6 in the Botanical Area this type, along with T. 204 which is very similar to it, was grown alternating with T. 5—a type susceptible to wilt.

The results obtained are given below:—

Type	No. of plants	No. wilted	Percentage of wilt
T. 80	73	4	5·5
T. 204	62	6	9·6
T. 5	86	66	67·6

In another plot, Bara 8, T. 80 was grown on a larger scale but the results obtained are not satisfactory as compared to those obtained in Bara 6 given in the table. Out of 1,062 plants of T. 80 in this plot, 647 or 60·9 per cent. wilted. This high wilt percentage was due to growing *rahar* on *rahar*-sick soil, for continued cropping with *rahar* on a particular piece of land is to be expected to affect the vitality of the plant and render even a resistant variety liable to increased mortality. The degree of resistance is brought out well by the behaviour of the same resistant type, *i.e.*, T. 80 in the fourteen Punjab permanent manurial plots, a quarter of an acre each, where it was grown during the year and only three deaths took place.

In the table below, the average number of wilted plants in each plot for the previous six seasons in which susceptible *rahar* types are grown there, also the number of wilted plants in each plot during the previous season and the number of wilted plants in the resistant Type 80 are given. The results are in conformity with those of last season and indicate that Type 80 has a high degree of resistance.

Plot number	I	II	III	IV	V	VI	VII
Plot average . .	382	397	202	567	240	175	196
1928-29 . . .	467	350	213	382	160	167	96
1931-32 . . .	0	0	0	0	0	0	0

Plot number	VIII	IX	X	XIII	XIV	XV	XVI
Plot average . .	1,006	1,186	1,325	267	195	292	567
1928-29 . . .	912	987	1,049	127	151	213	382
1931-32 . . .	1	0	0	0	0	0	2

In order to see whether the *rahar* strain of *Fusarium vasinfectum* can infect cotton and sann-hemp, 220 plants of cotton and 819 plants of sann-hemp were grown in a plot behind the outside laboratory which for several years has been very heavily infected with the

rahar strain of *Fusarium vasinfectum*. Thirty plants of cotton and 48 plants of sann-hemp died and *Fusarium* mycelium was observed in the vascular tissues. The deaths took place at a very late stage but it is not yet definitely established whether the death was due to the *rahar* strain of *Fusarium vasinfectum* or not. A susceptible *rahar* type, cotton and sann-hemp have again been sown in the same infected plot this year to find out whether wilt is produced in the latter two crops.

Cercospora indica n. sp. A study of two strains of a new species of *Cercospora* was continued and a large number of cross-inoculation experiments were carried out on various pulses such as *Phaseolus aconitifolius, P. radiatus, P. mungo, Dolichos lablab, Vigna catjang, Glycine hispida,* but none of them took infection. Both these strains differ remarkably in symptoms on the host plant, shape, size or septation of conidiophores and conidia from two other species, *viz., C. cajani* P. Henn (*Vellosiella cajani* P. Henn and Rangel) and *C. instabilis* Rangel recorded on *Cajanus indicus* elsewhere. Further the Indian species does not agree with any other known *Cercospora* and is considered to be a new species. The name *Cercospora indica* n. sp. has therefore been proposed. A paper entitled "Studies on *Cercospora indica* n. sp." by U. B. Singh was written for publication in the *Indian Journal of Agricultural Science.*

(*ii*) Dolichos lablab

A study of *Cercospora dolichi* E. and E. on *Dolichos lablab* was continued. This species can infect *Phaseolus aconitifolius, P. radiatus, P. mungo, Glycine hispida, Vigna catjang* when artificially inoculated. Observations made during the last three years showed that the fungus is in its virulent form during February and March. The optimum conditions of growth of this fungus under artificial conditions of growth in the laboratory are comparable with the natural conditions for the spread of the disease during February and March as shown by the study of the meteorological records for the last three years at Pusa. Butler has suggested (*Butler, E. J.* Fungi and Diseases in Plants, page 261, 1918) that *C. dolichi* and *C. cruenta* Sacc. are probably identical, but a comparison of *C. dolichi* E. and E. with *C. cruenta* Sacc. isolated from *Phaseolus aconitifolius* under artificial conditions of growth showed that *C. dolichi* is quite different from *C. cruenta* Sacc. Further, two saltants obtained from the parent culture of *C. dolichi* also differed from the four saltants got from the parent culture of *C. cruenta.* Though both these species differ from each other morphologically and physiologically, yet they can infect the host of each other when inoculated artificially.

(*iii*) Sugarcane

Mosaic disease. Mosaic was recorded on Co. 285, Co. 328, Co. 331, and Co. 337 in Sepaya farm in North Bihar. All the other varieties known to be susceptible to this disease have been recorded in previous reports.

The whole area of thirty-seven acres under sugarcane in the Pusa farm was rogued, and the varieties affected with disease, together with the area under cultivation, were as follows:—

Area in acres	Variety	Clumps infected	Per cent. infection
10·44	Co. 210	24	0·01
9·77	Co. 213	7	0·05
2·71	Co. 281	2	0·001
1·39	Co. 299	2	0·01
0·85	Co. 303	1	0·01

Altogether 22 Coimbatore varieties were under field trials and 34 were grown in the nursery. All these varieties, except the five mentioned above, were free from the disease.

The experiment to test the natural spread of mosaic was repeated and laid down in March 1931. A row of each of 25 varieties alternated with a row of Co. 213, mosaic-infected cane. All the varieties tested were free till the middle of October when owing to high winds the canes lodged, and further observations were difficult to make until the cutting time when Co. 312 and Co. 313 were found to be infected, the percentage of mosaic being 4·4 and 16·5 respectively. The same experiment was laid down again in February 1932 with the following 34 varieties using Co. 213 as mosaic material:—Katha, Saretha, Chunnee, Uba, Hemja and Co. 210, 213, 214, 223, 285, 290, 304, 312, 313, 315, 316, 320, 321, 322, 323, 324, 325, 326, 327, 328, 329, 330, 331, 332, 333, 334, 335, 336, 337.

Symptoms of mosaic appeared during April and May on the following varieties in the plot where they were inter-stripped with mosaic-infected Co. 213 and the numbers indicate that the vector was more active here this year than last.

Variety	Clumps infected	Per cent. infection
Saretha	22	22
Chunnee	3	3
Co. 210	19	17
,, 213	8	7
,, 304	20	16
,, 312	1	1
,, 313	46	48
,, 327	1	1·1
,, 332	1	1·3
,, 337	1	1

Tonnage experiment. A paper entitled "Effect of mosaic on the yield and juice of sugarcane in Pusa", giving results of last year's investigation, was written up and published in the *Indian Journal of Agricultural Science*, Vol. I, Part V, pp. 527-533, 1931, and the experiment was continued. Thirty-two plots, each 5 by 66 yds. of Co. 213, were laid down in adjacent pairs, half of them with mosaic-free and half with mosaic cane in the order as follows: mosaic-free, mosaic, mosaic, mosaic-free, and so on. The area was good, even, heavy land suitable for growing

sugarcane, and its parts had been subject to the same field rotation in previous years. Immediately before this year the crop it held was sugarcane. Great care was taken to see that both the mosaic-free and the mosaic cane really conformed to these descriptions so that they are beyond doubt. A small amount of infection spread to the mosaic-free plots, altogether there being 22 clumps of mosaic, four plots having one clump each, five having two each and one having eight. Such small numbers have a quite inappreciable effect on the weight of the stripped cane. This small spread to healthy cane in plots in such close juxtaposition to mosaic-infected cane as they are, indicates how few and how inactive insects were during the season in spreading the disease. The mean percentage of infection with insects was as follows:—

Insects	Mosaic-free	Mosaic
Top shoot borers (*Scirpophaga nivella* Fabr.)—		
Early attack	39·5	41·0
Late attack	14·4	15·7
Stem-borers (*Argyria sticticraspis* Hmpn., *Diatræa venosata* Wlk., *Chilo zonellus* Swinh.)	1·7	1·7
Root-borer (*Emmalocero depressella* Swinh.)	4·6	4·5
Termites	1·5	1·6

The mean difference in each case is small and has no statistical significance; whatever loss was caused by these insects was so evenly distributed that it did not have an effect on the difference of the mean tonnage of the plots. No damage was done by cane diseases caused by fungi as there were no stem diseases and the leaves were comparatively free from spots, and none was caused by animals. After removing cane to eliminate edge effect the plots were five by fifty yards and the yield of stripped cane in maunds (82·28 lb.) was as follows:—

Weight in maunds (82·28 lb.) of stripped Co. 213

Mosaic-free	Mosaic	Mosaic-free	Mosaic
38·71	33·60	43·27	37·56
47·32	40·57	47·28	38·46
45·10	34·61	42·50	38·00
44·32	36·96	48·27	39·71
44·30	38·61	46·32	44·28
45·76	38·94	47·19	39·13
44·72	34·36	44·04	40·53
44·25	35·31	44·20	40·15
Mean 44·84	38·17		

Difference 6·67 or 14·8 per cent.

The mean sucrose percentage was 16·27 in mosaic-free and 15·60 in mosaic-infected, the mean difference being 0·67 or 4 per cent.

Samples from all plots were analysed by the Imperial Agricultural Chemist and the details are on the next page.

Sugarcane tonnage plots 1931-32 Mosaic-free versus Mosaic samples taken from 22nd to 26th February 1932

Plot numbers		Weight of cane in lb.		Weight of juice in lb.		Percentage weight of juice to cane		Brix (corrected)		In juice					
										Sucrose per cent.		Glucose per cent.		Purity per cent.	
F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M
1	2	139	136·5	92·5	88·5	66·5	64·8	19·47	18·47	16·34	15·21	0·63	0·67	83·90	82·34
4	3	163	140	106·5	93	65.3	64·4	18·98	18·71	16·05	15·75	0·59	0·49	84·58	84·18
5	6	136	109·5	85·5	68·5	62·8	62.5	18·75	18·31	15·45	14·87	0·77	0·72	82·39	81·20
8	7	150	147	98·5	94·5	65·6	64·2	19·27	18·97	16·07	15·77	0·70	0·49	83·39	83·15
9	10	179	141	120	92	67	65·2	19·44	19·05	16·42	16·01	0·59	0·57	84·45	84·02
12	11	147·5	141.5	96·5	92	65·4	65	19·62	19·29	16·55	15·16	0·50	0·50	84·34	83·79
13	14	127·5	129·5	83·5	85	65·4	65·6	18·77	18·77	15·52	15·60	0·65	0·59	82·68	83·12
16	15	140	105	90	67·5	64·2	64·2	19·64	18·51	16·57	15·28	0.55	0·63	84·36	82·58
17	18	121	106	78·5	68	64·8	64·1	19·01	18·65	15·73	15·23	0·66	0·75	82·75	81·64
20	19	123·5	104	79·5	67	64·3	64·4	19·37	18·63	16·32	15·15	0·66	0·82	84·26	81·34
21	22	143	113·5	92·5	73	64·6	65·1	19·17	18·51	16·15	15·14	0·50	0·63	84·25	81·82
24	23	126·5	138·5	80·5	88	63·6	63·5	19·62	19·24	16·48	16·15	0·53	0·57	84·03	83·94
25	26	131·5	145	83·5	95	63·4	65·5	19·72	19·24	16·73	16·14	0.51	0·51	84·81	83·90
28	27	143	128	94·0	84	65·7	65·6	19·64	17·60	16·46	14·06	0·58	0·85	83·84	79·92
29	30	146	139	94·5	87	64·7	62·5	19·91	19·38	17·07	16·35	0·47	0·50	85·72	84·36
32	31	121·5	132	78	84·5	64·1	64·0	19·75	19·45	16·12	16·80	0·50	0·52	81·63	86·38
Mean . .		139·9	128·4	90·9	82·8	64·8	64·4	19·38	18·80	16·27	15·60	0·587	0·613	83·84	83·09
Difference .		−11·5		−8·1		−0·4		−0·58		0·67		−0·026		0·75	

The hydrogen-ion concentration of the juice was taken immediately it was extracted from the cane. The mean difference is within the limit of the error of experiment, so has no significance.

The statistical figures calculated by "Student's" method to determine the significance of the difference in yield between the series of pairs of plots are summarised below:—

Co. 213	Mean difference	Standard deviation	Mean difference / Standard deviation	Odds
Cane yield	6·67	2·39	2·8	Very great.
Juice	8·0	10·7	0·75	170:1
Percentage juice to cane	0·4	1·0	0·4	7:1
Brix	0·58	0·15	3·8	Very great
Sucrose	0·67	0·50	1·3	9999:1
Glucose	0·026	0·08	0·32	6:1
Purity	0·75	1·81	0·41	13:1

Thus the difference of weight of cane, weight of juice, brix and sucrose are all statistically significant but not those of percentage of juice to cane, glucose and purity. This year then the loss in weight of stripped cane was 14·8 per cent., while the quality of the juice had deteriorated as shown by a small decrease in brix and sucrose. The loss in such conditions therefore would be about 15 per cent. of cane to the grower and four per cent. of sucrose to the manufacturer. These differences were greater than occurred last year but the experiment will have to be carried on for some time yet before it can be determined whether they come within the range of annual oscillations or whether in the process of vegetative reproduction the effect of the virus disease in successive generations is cumulative.

Survey. An estimate of mosaic disease carried out last July fairly regularly along a line of 120 miles in North Bihar was made by actual count. This average as compared to the 1927 average was as follows:—

Co.	1927			1931		
	Area in acres	Localities examined	Percentage of mosaic	Area in acres	Localities examined	Percentage of mosaic
213	39·5	6	0·3	13·6	8	0·2
205	6·7	4	15·0	1·0	4	9·0
210	5·0	1	0·5	1·16	3	0·96

Infection experiments. The disease has been transmitted to Co. 213 from Co. 302, Co. 304, Co. 313.

Co.	No. of shoots inoculated	No. of shoots showing infection	Inoculation period (days)
302 to 213	20	17	21
313 to 213	20	20	21
304 to 213	20	20	18

Helminthosporium. A comparative study of all the species of *Helminthosporia* occurring in Cuba, *viz.*, *H. ocellum* Faris., the cause of eye-spot, *H. stenospilum* Drech., the cause of brown stripe, and *H.* sp., the cause of target blotch, and *H. sacchari* Butl. occurring in India, was continued. A highly sporing saltant (S. 8) with larger and more septate spores derived from *H. sacchari* was also taken for comparison. All the five species or strains were grown on a number of media and their growth characters were compared. They all differed from each other in cultural characters such as intensity of sporulation, zonation, the amount of aerial mycelium and colour, on certain media, while they resembled each other to a certain extent on certain other media and appeared to be closely allied, especially *H. sacchari* and *H. ocellum* though the saltant of *H. sacchari* (S. 8) differed from the parent even to a much greater extent. All the species had zonation on standard synthetic agar and the colour was brownish drab at 20°C. with very slight variation. The range of spore measurements of all strains and species under standard conditions of growth was found to fall within the range of *H. sacchari* and its several saltants. The size and septation of spores in *H. stenospilum* and S. 8 were alike. Observations showed that the spots formed by *H. sacchari* and spore size and septation closely agreed with those of *H. ocellum* Faris.

A large number of inoculation experiments were made by spraying spore suspensions in water on a number of cane varieties, especially Co. 213, Co. 316 and Red Mauritius, and all took infection readily, though the degree of virulence varied on different varieties of cane and among themselves. Further, it was observed that the type and colour of spots formed by different species and strains differed very slightly from those of each other and the type of spots formed varied from variety to variety, the difference being so slight that it was practically impossible to distinguish them by their spot characters. Even *H.* sp.—the target blotch fungus—failed to produce the typical target blotch spots on any cane variety tried.

A large number of saltants were obtained during the course of cultural studies, and these were tested to determine their stability and compared on a number of media. The conclusion drawn so far is that *H. sacchari* Butl. and *H. ocellum* Faris. are identical

though they are different strains, and the name *H. sacchari* Butl. with its amplified description (Mitra, M. *Trans. Brit. Mycol. Soc.*, XV, 254, 1931) should be maintained for the eye-spot disease in Cuba. Further work is in progress.

Yellowing of canes. A peculiar yellowing of canes in the varieties grown at Pusa and in the Saran District appeared after the heavy rains in July 1931. The leaves began to turn yellow from tip downwards and later on dried up, the mid-rib remaining green for a long time. Reddish streak and spots appeared on the leaf surface. The withered leaves presented a drooping appearance and in advanced cases the whole crown drooped and gradually died. Generally the 3rd, 4th, 5th and 6th leaves from the top showed the yellowing. Both healthy and yellowed canes could be seen in the same clump. The general appearance was that of premature ripening. The lower layers of roots were mostly dead, black with soft cortex, while the surface roots were alive. On cutting open the stem, red streaks were sometimes seen; in advanced cases the pith became discoloured and hollow. The yellowed canes were found invariably attacked by borers, the damage varying from 2 to 68 per cent. Two strains of *Rhizoctonia*, a Basideomycetous fungus, two strains of *Fusarium* and one species of *Verticillium* were isolated from diseased specimens and their parasitism is under investigation.

(*iv*) Hibiscus sabdariffa

Stem-rot. A stem-rot disease has been doing considerable damage for the past few years in Pusa. Seed is sown in July but the disease becomes manifest only in January, long after the plant has started flowering. The portion of the stem nearer the inflorescence first assumes a straw brown colour which ultimately becomes whitish brown. This patch girdles the stem and advances both above and below, and a dry rot sets in. Leaves at this time are usually shed and the plant does not droop. The bolls that may have formed near this region and above are usually not fully developed, sclerotia of the fungus are found in the placental region, and the seeds shrivel up. Dark sclerotia are also formed on the surface of the stem and in the pith.

A fungus resembling *Sclerotinia sclerotiorum* (Lib.) Mas. has been isolated, which can grow on a variety of nutrient media, and the mycelium forms characteristic sclerotia within ten days of seeding on agar. The sclerotia are irregularly-shaped black bodies and exude some yellowish liquid drops.

A temperature relation study has revealed that the optimum for growth is around 22°C., and the reason why the disease becomes manifest in the cold weather is thus evident. At about 33°C. the fungus ceases to grow but the thermal death point seems to be above 50°C. Diseased tissues collected in March 1931 failed to demonstrate the presence of the fungus in October that year; even the sclerotia

that had been collected at that time from diseased stems did not possess the power of germination, while sclerotia mixed up with seed left over from last year's (1931) planting were able to germinate, showing that the ordinary condition of seed storage favoured the survival of the sclerotia.

Grown in liquid media adjusted to various acid and alkaline reactions, the fungus showed a preference to acid reaction. Good aeration seemed to be necessary for abundant sclerotial formation. The fungus, it was noted, formed appreciable quantities of oxalic acid. Sclerotia planted in moist sand and placed at about 6°C. were able to put forth finger-like processes which seem to be incipient attempts to form the perfect stage, and whether the fungus will form apothecia is awaited with interest. In a potato-dextrose agar tube, the Botrytis stage was noted.

As the seed is mixed up with sclerotia, a method of separating them by determining the specific gravity of both was attempted, and it was found that the specific gravity of seed and sclerotia was 0·83 and 0·88 respectively. These figures are too close to be of any use at present. The formation of sclerotia within the seed appears to be an important method of dissemination of the fungus. Further work is in progress.

(*v*) Rice

Sclerotium oryzae. A small but constant damage is done to paddy in India by *Sclerotium oryzae* Catt. The fungus seems to be co-distributed with its host and has been reported from all the provinces. By inducing excessive tillering and sterility in grain and in certain cases rotting the stems of the rice plant the fungus causes a loss of both straw and grain. Studies on the fungus with a view to know its complete physiology, racial specialization if any, and factors which control its parasitism have been undertaken. Strains from Burma, Punjab, Bengal, U.S.A. and Ceylon have been collected and attempts are being made to get them from other centres also.

In order to determine how long sclerotia of *S. oryzae* survive, a large amount of paddy stubble with plenty of sclerotia was collected in March 1931 and the germination percentage of sclerotia was tested every month. The percentage of germination just after collection was found to be 87 and the sclerotia remained viable uptill October of the same year when it was found to be 76. After October the germination fell down to less than 4 per cent. in January 1932. The interval between the harvesting of the crop and the viability of the sclerotia being over eight months, rice fields will have to be left fallow for over a year to reduce infection, which procedure is not practicable under ordinary conditions.

Kerol was tried for controlling *S. oryzae* but no conclusive results were obtained.

(*vi*) Gram

Mystrosporium n. sp. The climatic conditions were quite unfavourable for the development of the leaf blight fungus *Mystrosporium* sp. which has so far been recorded only from Pusa. Rains during the winter months generally favour the spread of this disease but this year there had practically been no winter rain and the weather was dry. During 1930 the blight was present on 88 types of gram grown in the Botanical Area at Pusa, in 1931 it appeared on 61 types of gram, while during the year under report its presence was noticed on one type only, *viz.*, T. 68. This type is most susceptible.

The treatment of seed on a field scale with 0·5 per cent. formalin for 30 minutes was again carried out but no conclusive results were obtained on account of unfavourable climatic conditions. The disease did not appear even in plots sown with heavily infected gram seeds. Further trials will be made.

The morphology of the fungus was studied in detail, and it is considered to be a new species of *Mystrosporium* hitherto undescribed. The study under artificial conditions of growth was repeated and the results obtained previously were confirmed.

(*vii*) Piper betel

The study of the three fungi, *viz.*, *Phytophthora* sp., *Rhizoctonia solani* and *Sclerotium rolfsii*, which cause considerable damage to *Piper betel* was continued. Their presence was first recorded from the deltaic regions of the Ganges, Brahmaputra and Padma rivers in Bengal. Since then they have been recorded from time to time from diseased specimens received from Assam, and during the year under report from three Central India States, *viz.*, Maihar, Chhatarpur and Nagod. *Phytopthora* has also been reported on this crop from the Central Provinces, Bombay and Madras. Thus these diseases of betel-vine are fairly well distributed throughout India wherever betel-vine is grown.

Cultural work with the *Phytophthoras* from Bengal, Madras and Malaya was continued, and to this study were also added strains isolated from specimens recorded from the three States mentioned above and one received from the Bombay Presidency. All the strains or species were compared by growing them at different temperatures, and four hundred sporangia of three *Piper betel* strains (Bengal, Madras and Malaya), *P. colocasiae*, *P. parasitica*, *P. palmivora*, *P. meadii*, *P. faberi* and one isolated from cinchona seedlings were measured under standard conditions of growth and compared. Statistical analysis showed that sporangia length, width and length/width cannot be used as a criterion for specific determination and that alone has no taxonomic importance. Further inoculation and cross-inoculation experiments were carried out with all the strains and species of *Phytophthora* on the leaves

of *Colocasia antiquorum*, castor, cotton, and betel-vine, and the results of last year were confirmed.

Spraying with Bordeaux mixture gave satisfactory results in checking the disease caused by *Phytophthora* but has not been found so effective with *Rhizoctonia* which in some places causes a very considerable number of deaths immediately after the rains and in the cold weather. Efforts are being made to control *Rhizoctonia* by means of soil disinfectants. Kerol of a concentration of one part in 1400 (0·07 per cent.) kills the fungus wherever it comes in contact with it. Applied to the soil, 0·07 per cent. Kerol kills the mycelium in the soil, but not the mycelium inside the infected stems which have not thoroughly decayed. Such infected pieces of stems must be hand-picked and removed in order that this method of prevention becomes effective, or, in other words, Kerol treatment and sanitary upkeep of betel-vine *borojes* must go hand in hand. Experiments are being conducted in Bengal with Kerol and so far satisfactory reports have been received.

Sclerotium rolfsii appears so seldom that no preventive measures have been undertaken against it but its reaction to a soil disinfectant is also being examined.

A paper entitled "Foot-rot diseases of betel-vine in Bengal" is ready for publication.

(*viii*) Cinchona

The study of *Phytophthora* sp. which causes seedling blight of cinchona was continued. Four hundred sporangia were measured and compared with 400 sporangia of eight other species of *Phytophthora* under standard conditions. A large number of inoculation experiments were carried out on *Colocasia antiquorum*, castor seedlings and betel-vine. Cinchona *Phytophthora* was able to infect castor seedlings but not *Colocasia* and betel-vine, while betel-vine *Phytophthora* infected cinchona seedlings and castor seedlings. In cultural characters cinchona *Phytophthora* agrees with *P. palmivora* and like the latter it does not grow at a temperature of 35°C. or above.

(*ix*) Tobacco

Alternaria sp. A leaf spot disease was found to do considerable damage to tobacco on the Rangpur farm in Bengal, making the leaf unsuitable for cigar wrapping. The disease first appeared as small straw coloured spots scattered all over the surface of the leaf, but gradually they increased in size and later on were surrounded by a light brown ring. The centre of the affected tissue gradually became brittle and in severe cases the diseased tissues were soon cut off from the rest of the leaf and ultimately fell out, leaving a round hole in the leaf giving the appearance of a 'shot hole'. The fructification appeared in the dead portion of the spot. A species of *Alternaria* was isolated and infection experiments carried out

proved its pathogenicity. The morphology of the fungus on the host and cultural characters on artificial media of varying constituents were studied. Further study is in progress and it is being compared with other species of *Alternaria*.

Stem-rot. On the same farm some tobacco plants showed a wilted appearance; the stem of the diseased plants when split open showed the presence of greyish mycelium and sclerotial bodies in the central hollow caused by disintegration of the pith.

The fungus was brought into pure culture and was found to be a species of *Sclerotinia*. Physiological study on artificial media and infection experiments are being carried out.

(*x*) Wheat

A species of *Alternaria* occurs every year on wheat at Pusa and forms brownish spots with a pale yellow ring on the leaves. Spores of *Alternaria* are also often found on the seed-coat of wheat. The fungus causing leaf spot was isolated, and the infection experiments carried out proved that it is parasitic and capable of producing 'foot-rot' of wheat as well. Morphological and cultural studies of the organism have been undertaken to determine whether the organism causing leaf spot is identical with the one found on the seed-coat.

The percentage of leaf area destroyed by *Helminthosporium sativum* P. K. and B. and *H. tritici-repentis* Died. combined was estimated according to Tehon's method on various varieties of wheat grown in Pusa and is compared with that obtained last year in the following table.

Wheat	1930-31	1931-32
P. 4	20·3	17·5
P. 12	3·2	1·8
P. 52	2·1	17·3
P. 80—5	15·6	18·5
P. 111	22·4	14·8
P. 114	...	13·3
P. 115	4·3	7·0
P. 163	2·8	4·6
Country	3·2	2·0

P. 4, P. 111 and P. 80-5 were heavily infected as last year though the severity of the disease was less, while P. 52, which was least infected last year, was heavily attacked.

Wheat cultures grown at the Botanical Sub-station at Karnal were also examined for *Helminthosporium*, and it was found that all the varieties were almost free from it.

Wheat rust. A survey of rust on all the varieties of wheat grown in the Botanical Area was made as in previous years. The orange rust appeared as usual during X'mas, and was first noticed on the 26th December, 1931. The yellow and black rusts were first noticed on the 16th January and the 5th February, 1932, respectively. The year being dry and unfavourable for the spread of rust, the attack by orange rust was mild. Yellow rust was rather bad on P. 52 and P. 115. Most of the other varieties remained almost free. Black rust was also mild, and as it appears late when the ears are formed and maturing, the damage done was not appreciable. The early varieties escaped the attack from black rust altogether.

The surface of the leaf covered by the rust postules was measured as in previous years (Tehon's method) and the following results were obtained:—

Variety	Orange rust	Yellow rust
P. 4	Traces	...
P. 12	1·0	Traces
P. 52	Traces	5·4
P. 111	0·7	...
P. 114	1·2	...
P. 115	Very light	8·0
P. 163	0·5	...
P. 80—5	Traces	...
Country	,,	1·0

A survey of wheat rust at the Botanical Sub-station at Karnal was also made. Orange rust was rare and only a very few cultures had a light attack while the rest had only traces. The average percentage of leaf area covered by orange rust ranged from 0·5—1·0, while yellow rust was bad, the percentage varying from 4—26·2 in different varieties. P. 52 and P. 115 were badly attacked by yellow rust, though not so heavily as last year. These two varieties appear to be unsuitable for growing under climatic conditions as obtain in Karnal. Of black rust there was practically none.

At the request of Professor K. C. Mehta who is investigating cereal rusts of India, aeroscopes were placed in wheat fields and exposed slides were sent to him at regular intervals. Similar slides were also exposed for the Section and careful microscopic examination revealed some diatoms and spores of saprophytic fungi. No rust spores were observed until after the appearance of rust in the fields.

(*xi*) Barley

An estimate of the percentage of leaf surface rendered ineffective by *Helminthosporium sativum* and *H. teres* was made again

by Tehon's method on various types of barley grown in the Botanical Area. As in previous years, *H. teres* was present on certain types of barley. A comparative statement of the intensity of the disease during 1930-31 and 1931-32 is given below:—

Type	1930-31			1931-32		
	Attacked by		Total attack	Attacked by		Total attack
	H. teres	H. sativum		H. teres	H. sativum	
1	1·8	4·1	5·9	1·0	2·6	3·6
2	..	3·0	3·0	..	1·2	1·2
3	1·2	1·2	2·4	..	1·4	1·4
4	6·3	..	6·3	..	5·2	5·2
5	12·1	..	12·1	1·0	3·9	4·9
6	27·9	..	27·9	23·2	..	23·2
7	21·2	..	21·2	25·4	..	25 4
8	10·6	4·5	15·1	17·5	6·1	23·6
9	..	8·4	8·4	..	12·5	12·5
10	1·3	10·8	12·1	1·6	14·2	15·8
11	8·2	1·0	9·2	4·5	10·1	14·6
12	5·9	3·7	9·6	4·8	4·3	9·1
13	7·5	0·9	8·4	3·0	2·7	5·7
14	7·1	1·1	8·2	1·3	5·7	7·0
15	1·2	11·0	12·2	..	5·5	5·5
16	..	7·3	7·3	..	4·1	4·1
17	6·0	..	6·0	0·5	4·7	5·2
18	12·2	..	12·2	15·0	..	15·0
19	15·9	..	15·9	20·1	..	20·1
20	..	9·3	9·3	..	4·8	4·8
21	17·7	..	17·7	4·0	3·1	7·1
22	14·5	..	14·5	5·2	5·1	10·3
23	13·4	..	13·4	17·9	..	17·9
24	9·2	..	9·2	3·6	4·0	7·6
Country	..	5·9	5·9	..	1·9	1·9

Seeds of 24 types of barley mentioned above were treated to control the two *Helminthosporiums*. The treatment was done as follows:—(*a*) No treatment, the figures for which are already given in the previous table; (*b*) seeds disinfected with formalin 1: 320 or a solution made by adding a bottle of formalin to 40 gallons of water (seeds kept soaked for 20 minutes and then under formalin vapour for 30 minutes); (*c*) seeds disinfected with uspulun (universal) 0·25 per cent. solution for one hour. The extent of damage to the leaves by the two species of *Helminthosporium* was estimated and the results are classified below:—

Damage	Control No treatment	Formalin treatment	Uspulun treatment
Very slight . .	*Nil*	Two types— 2, 3	Six types— 1, 2, 3, 4, 5, 17.
Slight . . .	Two types— 2, 3	Five types— 1, 4, 5, 17, 21	Twelve types— 11, 12, 13, 15, 16, 18, 19, 20, 21, 22, 23, 24.
Fair . . .	Thirteen types— 1, 4, 5, 12, 13, 14, 15, 16, 17, 20, 21, 22, 24.	Fifteen types— 8, 9, 10, 11, 12, 13, 14, 15, 16, 18, 19, 20, 22, 23, 24.	Five types— 7, 8, 9, 10, 14.
Bad . . .	Nine types— 6, 7, 8, 9, 10, 11, 18, 19, 23.	Two types— 6, 7	One type—6.

The above table shows that uspulun treatment controls the disease to a certain extent and is more effective than formalin treatment.

The experiment to test the resisting power of certain Pusa barley varieties to *H. sativum* was repeated. This year eight types of barley, *viz.*, 1, 2, 5, 7, 12, 17, 20 and 21, were taken, and seeds were treated before sowing as reported in the previous year. All the eight types of barley were sown in 200 plots with 160 seeds in each. Seedlings which died were removed and examined at regular intervals and the percentage of death due to foot-rot was determined. When the crop was fully grown, the percentage of leaf surface destroyed was estimated according to Tehon's method. The experiment will have to be repeated as on account of exceptionally dry weather conditions little disease appeared.

(*xii*) Chillies

The study of the wilt disease of chillies caused by *Fusarium* sp. reported last year was continued. All the isolations were examined in culture and proved to be similar in morphological characters. The disease was found in the Mysore plot during 1930-31 on four

types—T. 34, T. 41, T. 46 and T. 51—and it was severe in T. 51. During the year the wilt was not severe and its presence was noticed only in the Botanical Area and like last year was severe on T. 51. Preliminary experiments were carried out in test tubes where the seedlings were grown on Knop's solution. The seeds had been sterilized in 0·5 per cent. formalin and when the seedlings came up inoculations were made. The results are given below:—

Type	No. of seedlings	No. infected	Percentage of death
Type 34	92	78	84·7
Type 41	66	62	93·9
Type 46	90	75	83·3
Type 51	96	88	91·6

There were no deaths in the control in which only treated seeds were sown. Untreated seeds were also sown and in T. 34 there was one death out of 27, in T. 41 one out of 12, in T. 46 five out of 22 and T. 51 *nil* out of 24. The last treatment was carried out because *Fusarium* hyphae were noticed on several seeds when examined microscopically. The experiments were duplicated in pots and in fields but no conclusive results were obtained. The weather was exceptionally dry with no winter rain, which may perhaps be the cause of failure of infection experiments.

Observations made during 1930-31 showed that wilt was greater in plots manured with ammonium sulphate and superphosphate and even more in parts of low-lying plots liable to be flooded during rains. Similar observations were also made during 1931-32.

Fresh isolations have been made and it is proposed to continue the work.

IV. MISCELLANEOUS

Studies in Sclerotiums. Among the fungi that cause disease in crop plants in the tropics none perhaps do as much damage as the fungi belonging to the genera *Sclerotium* and *Rhizoctonia*. Since Saccardo found the species *Sclerotium rolfsii* in 1911 a good deal of work has been done on this fungus. Japanese workers have shown that the perfect stage of the fungus lies in the genus *Hypochnus*, but Curzi states that it is a *Corticium*. Complete studies have been made with American, Italian and Japanese strains. Indian strains of this fungus have not so far been taken up for serious study with the exception of one form occurring on the garden plant *Zinnia*. It is not known, for instance, if all the forms that form large and characteristic sclerotia are really referrable to the species *rolfsii* or to some other species. The fungus has been reported from graminaceous, malvaceous and a variety of other plants, but whether there is any parasitic specialization, variations in morphological and growth characters, and differences in physiological responses is not yet known. The perfect stage has not so far been recorded in India.

An exhaustive study has therefore been undertaken to elucidate information along the lines indicated above. There are at present seven strains available which have shown certain differences in their growth characters. The study is being conducted using as many criteria of differentiation as modern technique of experimentation has made available.

Studies in Rhizoctonia. Investigations on this fungus have been in progress in this laboratory since 1911. A great deal of information about it has already become known. The fungus, however, continues to play havoc with seedlings of many plants, and causes stem-rots and wilts of several others. In continuation of these studies, it is felt that more intensive investigations should be undertaken.

V. SYSTEMATIC WORK

A species of *Synchytrium* on *Trichosanthes dioica* and *Sclerotium sclerotinia* on *Helianthus annus* L. have been recorded for the first time in Pusa. A collection of species of citrus diseases in the Punjab was received from the Professor of Botany, Punjab University, and added to the herbarium. A large number of specimens and cultures received during the year from Professors of Botany in Indian Universities, Agricultural Officers, Economic Botanists and Mycologists in various Departments of Agriculture were identified. Specimens were also received for identification from the public and the Indian States. Fresh specimens of three rusts on wheat were sent to the Professor of Botany, Agra College, for his research on rust. Cultures and specimens were also supplied to several Professors of Botany in Indian Universities and also to Mycologists in several provinces. A supplementary list of fungi in the Mycological Herbarium at Pusa is being prepared.

VI. PROGRAMME OF WORK FOR 1932-33

1. Research work

New diseases of Indian crops that come to the notice of the Section will be investigated. Diseases on the following crops will receive special attention:—Cereals, sugarcane, *rahar*, *Piper betel*, cinchona, gram, chillies, tobacco and *Hibiscus sabdariffa*.

The investigations in progress include:—

(*i*) Experiments to determine the resistance of Co. varieties of sugarcane to mosaic and tonnage experiments to determine the loss due to mosaic.

(*ii*) Fungus diseases of sugarcane such as *Sclerospora*, top-rot and an obscure disease causing yellowing of canes.

(*iii*) Experiments to find out suitable remedial measures to check the diseases of *Piper betel*.

(*iv*) A study of diseases of cereals and sugarcane caused by species of *Helminthosporium* and *Alternaria*, and *Cercosporas* on pulses.

(*v*) Determination of percentage of rust and *Helminthosporium* on various varieties of wheat and barley.

(*vi*) Morphology and parasitism of *Fusarium* sp. causing wilt of chillies, *Mystrosporium* sp. causing leaf blight of gram and remedial measures.

(*vii*) Studies in *Sclerotium rolfsii*, *S. oryzae* and *Rhizoctonias*.

(*viii*) Stem-rot of *Hibiscus sabdariffa* due to *Sclerotinia* sp.

2. Training

Students and assistants will receive training on the lines indicated in the prospectus.

3. Routine work

Advice and assistance as required will be given to other departments and the general public.

VII. PUBLICATIONS

McRae, W. . . .	Effect of Mosaic on the Yield and Juice of Sugarcane in Pusa. *Ind. Jour. Agri. Science*, Vol. II, Aug. 1932.
McRae, W., and Shaw, F. J. F.	Influence of Manures on the Wilt Disease of *Cajanus indicus*. *Scientific Monograph No. of the Imp. Council of Agri. Res.*
Mundkur, B. B. . .	The Calculation of Probable Error of Mendelian Ratio. *Ind. Jour. Agri. Science*, Vol. II, pp. 42-46, 1932.
Singh, U. B. . . .	Physiology of *Cercospora dolichi* E. and E. Accepted for publication in *Ind. Jour. Agri. Sci.*

REPORT OF THE IMPERIAL ENTOMOLOGIST

(P. V. Isaac, B.A., M.Sc., D.I.C.)

I. ADMINISTRATION

Mr. T. Bainbrigge Fletcher, Imperial Entomologist, relinquished charge of his office on the 5th April, 1932, and proceeded on leave preparatory to retirement, and I took over charge as Officiating Imperial Entomologist, in addition to my own duties, with effect from the same date.

Rai Bahadur C. S. Misra, First Assistant, was on leave from the 15th February to the 24th March, 1932.

Owing to financial stringency, one post of Assistant and two of Fieldman (one temporary) were brought under reduction.

II. TRAINING

Mr. B. D. Gupta, M.Sc., post-graduate student, completed his course and left Pusa at the end of October 1931.

Two Lecturers of the Khalsa College, Amritsar, worked in the Section from the 20th July to the 14th August, 1931.

III. INSECT PESTS

Sugarcane

Intensive study was made of the early stages of cane-borers, specially *diatræa venosata* Wlk., *D. auricilia* Ddgn. and *Argyria stricticraspis* Hmpsn.

During July to October large numbers of *Pyrilla* spp. were present on sugarcane and after October they became fewer. During August, 3,873 egg-masses of these were collected from a plot measuring 0·04 of an acre under the variety Co. 213. Egg parasites reached their maximum activity in October during which month the parasitization of egg-masses was recorded as 51·1 per cent. in the second week, and 87·5 per cent. in the third week. From this period it declined and at the end of December it was only 20·2 per cent. During January a large number of egg-masses were found under the sheathing leaves and these showed a parasitization of 76·8 per cent.

Sugarcanes planted in February 1931, when examined in January 1932, gave the following results regarding borer-attack and damage by termites:—

Sugarcane planted—10th—13th February, 1931.

Examined—4th—6th January, 1932.

Variety of sugarcane	Number of canes examined	Borers per cent.	Termites per cent.
Co. 205	500	51·2	14·0
Co. 213	517	41·3	34·04
Co. 214	507	71·9	14·3
Co. 281	568	37·3	42·6
Co. 303	517	41·005	23·7

An examination in July of the cane stubble left in the field from the previous year's crop showed that 64·4 per cent. of the stems had cane-borers in them. These included *Argyria stricticraspis* Hmpsn., *Diatræa* spp. and *Emmalocera depressella* Swinh. In thick canes planted in February 1932, when examined in April 1932, there was 6·07 per cent. attack by *E. depressella* Swinh. Ratoon canes examined at the same time showed 17·8 per cent. attack by this root-borer.

Aphis sacchari Zehnt. was present on sugarcane during November and December. Wingless viviparous, as well as, alate viviparous females were present. Numbers of *Paragus* sp. and *Scymnus nubilans* Muls. were present on the infested plants, but these could not appreciably reduce the pest. Unlike last year, parasitization was considerably low. *Trionymus sacchari* Ckll. was also present in fairly large numbers in isolated patches. *Aleurolobus barodensis* Mask. was bad on some varieties of Co. canes, specially on cane planted in October 1931. In the latter, the infestation was so heavy that 72 to 97 nymphs and puparia were counted on a square inch of leaf surface. As in previous years, no active parasite was found on colonies of this white-fly of cane.

Other Pests

Prodenia litura Fb. considerably damaged castor, and *Spilosoma obliqua* Wlk. damaged *Sesamum indicum*, *Ipomaea batatas*, *Phaseolus radiatus* and *P. aconitifolius* during the year. *Urentius echinus* Dist. and *Phenacoccus insolitus* Green were bad on brinjal. Large numbers of *Zonabris phalerata* Pall. appeared during the beginning of September and damaged ornamental *Hibiscus*. *Eugnamptus marginatus* Pasc. damaged mango trees in the end of July when the plants were putting forth fresh leaves. *Pseudococcus corymbatus* Green was present in abnormal numbers on *Hibiscus sabdariffa*. In some plots the infestation was more than in the previous years. The apices of infested plants became hard and compact and the growth was retarded. The infested plants pre-

sented a grey-copperish tinge and, as such, could distinctly be seen in the fields. These were treated successfully by spraying the plants with rosin compound. *Pyroderces simplex* Walsm. was present in very large numbers on *bajra* (*Pennisetum typhoideum*) ears, specially such as were affected with *Fusarium* sp. and *Acrothecium lunatum* Wlk. along with *Stenachroia elongella* Hmpsn. *Agrotis ypsilon* Rott. considerably damaged potato tubers in the ground. *Agrotis flammatra* Schiff. also was found along with these. *Plutella maculipennis* Curt. did considerable damage to late varieties of cauliflower. *Dialeurodes pallida* Lamba was present in large numbers on betel-vines.

Trionymus sacchari Ckll. was reported as a serious pest of paddy in the Champaran District. The pest has been known in the locality for the last three years, but now it has spread over a large area. The infested plants turn pale yellow, and bear no grain.

Orthaga sp. was present in large numbers on the late ripening varieties of mangoes in the Darbhanga District. The pest was present in the locality for the last three years but no notice was taken, by the proprietors of the mango gardens, until the year under report. In the beginning of November last, caterpillars found feeding on the leaves were received for examination and steps were taken to investigate and treat the pest. By this time, winter had set in and the majority of caterpillars had pupated. The pest is still under investigation.

Specimens of tobacco seedlings received from the Superintendent, Botanic Gardens, Saharanpore, U.P., were found damaged by *Phthorimaea heliopa* Lower.

In the Insectary the life-histories of about a hundred insects were studied partly or fully and both coloured and black-and-white illustrations were prepared to record the results obtained. Investigation of the range of food-plants of various insects resulted in *Rhyncholaba acteus* Cram. being found for the first time feeding on leaves of grape-vine and *Prodenia litura* Fb. on leaves and branches of a medicinal plant known locally as *bramhi*. Larvae of *Euchrysops pandava* Houf. were collected from leaves of *Cycas revoluta* and the life-history of the insect was studied and figured. Specimens of the rare *Pterorthacris subcallosus* Uv., of which only the male form has so far been known, were collected from Pusa and for the first time the females were obtained.

The life-histories of certain Syrphid flies whose larvae feed on aphides in Pusa were completely worked out by Messrs. H. L. Bhatia and Md. Shaffi and a paper embodying the results has been submitted for publication.

Definite proof was obtained that the vesicular dermatitis, popularly known as "spider-lick", is caused by a Staphylinid beetle *Paederus fuscipes* Curt. These beetles are gregarious and are found hiding under spreading plants in damp soil close to rivers and water channels. Dusting with calcium cyanide was found effective for killing them.

The complete life-history of *Haematopota roralis* Fb., a widely occurring blood-sucking fly of cattle which also occasionally bites man, was worked out by me and a paper on the results has been submitted for publication. Other blood-sucking flies like *Tabanus speciosus* Ric. and *Chrysops pellucidus* Fb. were under investigation.

IV. BEES AND LAC

Apiculture. Advice regarding bee-keeping on scientific lines was given to 27 inquirers. One standard hive prepared by a Pusa carpenter under direction was supplied on payment. Artificial comb foundations for *Apis indica* prepared on the comb foundation machine in the laboratory were supplied to correspondents from different parts of India. Queen excluders required for apicultural work were also supplied to the public.

Lac. The lac crop was badly damaged in summer by the high temperature which reached the maximum of 112·3° in May. Larvae from *ber* (*Z. jujuba*) lac emerged from the end of June till the end of July and from the winter crop of *ber* lac the larvae emerged from the 17th October to the third week of November.

V. INSECT SURVEY

Collections were sent out for identification to the following specialists and their help is gratefully acknowledged:—

Coprinae to Mr. Arrow, London.

Psyllidae to Mr. Klyver, California.

Odonata to Herr. Lieftinck, Java.

Tabanidae to Prof. Szilady, Budapest, Hungary.

Diopsidae to Dr. Curran, New York, U.S.A.

Galerucine larvae to Mr. Maulik, London.

Odonata to Col. Fraser, Coimbatore.

Trichoptera to Mr. Mosely, London.

Thrips to Dr. Ramakrishna Ayyar, Coimbatore, Madras.

Insects of bionomic interest to Prof. Poulton, Oxford.

Culicidae to Capt. Barraud, Kasauli.

Indian insects were supplied to certain correspondents as listed below:—

Hispinae (larvae) to Mr. Maulik, London.

Ichneumonidae to the Government Entomologist, Madras.

Lucilia and *Chrysomyia*, *Sarcophaga* and *Bengalia* to Prof. Patton, Liverpool.

Locusts to Mr. D. Crerar, Sussex, England.

Some Grasshoppers to Prof. Mitchener, Manitoba, Canada.

Some Psyllid Galls to Assistant Entomologist, Lyallpur.

Rhynchota (including Pyrrhocoridæ) to Mons. Henri Goursat, Paris.

Insect specimens were received for identification from 61 correspondents and they were named as far as possible.

VI. CATALOGUE OF INDIAN INSECTS

The following catalogues were published during the year:—

(1) Alucitidæ (Pterophoridæ), by T. Bainbrigge Fletcher.

(2) Lycidæ, by Richard Kleine.

(3) Phaloniadæ Chlidanotidæ, by T. Bainbrigge Fletcher.

VII. PROGRAMME OF WORK FOR 1932-33.

Major

This will follow generally on the lines of work of the current year and will include general investigations of crop-pests and other injurious insects, and specially of the pests of sugarcane, fruit trees and stored grains.

Minor

Results in various lines of work require to be written up and published as far as possible. New insecticides and control methods will be tested as occasion arises. Systematic work will be carried on with our resources and the help of specialist correspondents. The Catalogue of Indian Insects will be proceeded with. Advice and assistance will be given as far as possible to Provincial Departments and to all inquirers on entomological subjects.

VIII. PUBLICATIONS

The following publications prepared by the staff have been issued during the year:—

(1) Bhatia, H. L. . . Studies in the Life-histories of three Indian Syrphidae. (*Ind. Jl. Agl. Sc.*, I, pp. 503-513, Pls. 1-3, August 1931.)

(2) Fletcher, T. Bainbrigge, and Sen, S. K. A Veterinary Entomology for India, Part 14. (*Ind. Jl. Vet. Sc. Anim. Husb.*, I, pp. 192-199, Pl. 1, September 1931.)

REPORT OF THE IMPERIAL AGRICULTURAL BACTERIOLOGIST

(N. V. Joshi, B.A., M.Sc., L.Ag.)

I. ADMINISTRATION

Mr. J. H. Walton held charge of the Section from the 12th November, 1931, to the 31st March, 1932. During the rest of the period I was in charge of the Section.

II. TRAINING

There was no admission of post-graduate students during the year.

III. SOIL BACTERIOLOGY

Nitrogen Fixation

The two series of rotation experiments started two years ago to test the influence of leguminous crops on the conservation of soil nitrogen were continued. As in previous years, the figures for total nitrogen remaining in the soil at the end of two years were less than at the beginning of the experiment; taking into account the nitrogen removed by the crops, however, a gain in nitrogen is noticed in all the plots. The highest gain calculated in this way is 265·4 lb. per acre in one series with a mixed crop of maize and *urid* (*P. radiatus*) grown in the *kharif* (summer) season and 128·9 lb. per acre in the second series with *kerao* (*Pisum arvense*) and barley grown mixed in the *rabi* (winter) season. The mixed crops have given comparatively better economic returns.

The comparison of the value of *Crotalaria juncea* and *Crotalaria sericea* in small plots was continued. *Crotalaria sericea* again did not maintain its higher yield observed in previous years, but showed a decrease of about 25 per cent. It is considered that the previous higher yields with *Crotalaria sericea* were due not to its superiority as manure but to the lowering of the yield brought about by white ants in the plots manured with *Crotalaria juncea*. The higher amount of nitrogen added every year by *Crotalaria juncea* as compared to *Crotalaria sericea* may also account for the result.

The soil nitrogen in *dhab* (low-lying) area showed seasonal fluctuations as in previous years; and the comparison of figures of analysis made in the same month for the last four years shows that the nitrogen in this area is well maintained by the cropping system employed. So these determinations will be discontinued after this year.

Green Manures

In previous years the manurial value of sann-hemp and *urid* was found to be equal. As the seed of *urid* is, however, cheaper, *urid* was compared with sann-hemp on a large scale in the farm

area. These two green manures were again compared with the sann-hemp tops applied later in the season so as to secure the stems for getting fibre out of them. The net profits reported after meeting the cost of production are as under.

	Rs.	A.	P.	
(1) Wheat after maize	3	12	0	per acre.
(2) Wheat manured with *urid*	16	2	4	,, ,,
(3) Wheat manured with sann-hemp . .	20	8	0	,, ,,
(4) Wheat manured with sann-hemp tops and fibre extracted from the stems . . .	41	1	8	,, ,,

It appears, therefore, that the cheapness of *urid* seeds has not contributed towards an economic return. The method of using sann-hemp tops for manuring and the stems for fibre, has increased the profits by 100 per cent. over the usual practice of ploughing in sann-hemp. In other words, it means that in the new method of using sann-hemp tops for manure, the season for growing sann-hemp is not wasted as in the usual practice but brings a money return in the value of the fibre in addition to that for wheat. To the ordinary cultivator who can extract the fibre in his spare time himself, this modified method of green-manuring would bring a further additional income, as he need not make cash payment for the labour involved in extracting the fibre as on a government farm.

Another way of not wasting the season and land for growing green manures is to grow them along with some other crop. Last year this was tried on a small scale by growing Mexicon sunflower (*Tithonia diversifolia*) in a plot of onions. This year it was extended to a larger area. In sixteen plots, each measuring 8·5 ft. × 22 ft., growing onions, cuttings of the Mexican sunflower were planted in the beginning of March. Sixteen other plots of the same size were left as controls. The results show that control plots with onions alone yielded on an average 187·9 maunds per acre, while the other set with sunflower yielded 169 maunds of onions per acre and 420 maunds of sunflower per acre. This quantity of sunflower would suffice to manure one and a half acres of land. Tops of this sunflower when used as green manure compared favourably with sann-hemp tops weight for weight. The yield of wheat after sunflower was 10·1 per cent. higher than that obtained by application of sann-hemp.

Nitrification

An experiment was started last December to note the seasonal effect on nitrifying flora in field soils by studying the nitrate production after addition of cake or ammonium sulphate to samples of soil taken once a month in a plot left fallow. At the same time soil was stored in a pot in the laboratory and samples were drawn for comparison along with those from the plot. It has been observed in the first three months December to February that the rate of nitrate accumulation was about the same. In March the rate of nitrification was higher than in the first three months and in April it came to the same level as in winter months, but in May and

June it again rose to the March level. In the soil stored in the laboratory, the rate of nitrate in each monthly sample has continued to rise up to the last sample taken in June with the exception of the April sample. Inoculation of these samples in Omeliansky's solution and determination of nitrates confirm the above observations, showing that the nitrifying organisms in Pusa field soil are affected by the seasonal changes.

Four years back soils from plots in the permanent experiments in the Punjab field were examined to find whether there was any difference in their bacterial activities. At that time very little difference in the decomposition of added oil-cake, as regards nitrate formation and carbon dioxide production, could be found, and it was inferred that there is no change in the number and kind of bacteria in spite of the variation in their nitrogen content and yield of crops. Fresh samples were taken this year from five plots, Nos. 3, 10, 12, 13 and 16, at intervals of one month since December, and the rate of nitrification of added oil-cake and ammonium sulphate observed by weekly determinations in nitrates. A difference in the amount of nitrate was observed up to the end of the first three weeks after the addition of oil-cake or ammonium sulphate. The soils from plots Nos. 16 and 10 treated with "green manure and superphosphate" and "complete mineral manures" were ahead of those from "farm-yard manure No. 3" and "green manure No. 12" which were better than that from "no manure No. 13".

In previous years it was reported that the addition of cyanamide to some soil failed to show any accumulation of nitrates, even after incubation for twenty weeks and more, although ammoniacal nitrogen was found in fairly large amounts much earlier, *i.e.*, after a short period of incubation for two or three weeks. Seven such soils were kept in the incubator, moisture being made up at intervals, to determine the products of decomposition of cyanamide, and the incubation was carried for over a year when it was found that between 67 and 71 weeks, the period varying with the soil, 90 to 100 per cent. of the nitrogen added as cyanamide was found in the form of nitrates. It is evident, therefore, that toxic substances like dicyandiamide evolved from cyanamide persist in the soil for a varying period depending on the nature of the soil and retard the progress of nitrification, but they are ultimately decomposed and converted into nitrates without loss of nitrogen. As nitrates were formed in these soils without resorting to inoculation of nitrifying organisms it is inferred that toxic bodies like dicyandiamide formed during the decomposition of cyanamide could not kill nitrifying organisms originally present in the soils.

Bacteriological analysis of soils under irrigation and under dry farming was continued. Samples were taken at different depths down to 36 inches. There was no marked difference in ammonification of peptone, nitrification of ammonium sulphate and nitrogen fixation in Ashby's mannite solution between the samples from the irrigated and unirrigated plots. The number of organisms and the

total nitrogen appear to be higher in the irrigated soil than in the unirrigated soil. The change is slow and will take some more time to be appreciable.

IV. BACTERIOPHAGY

Last year a bacteriolytic principle capable of dissolving the suspension of cultures of nodule organisms was isolated from root nodules of different legumes, and it was suspected that a similar bacteriophage might be associated with roots of the cereals which are known to derive a certain amount of benefit from the inoculation of the root nodule organisms. Attempts were made to test the presence of and to isolate the phage from the roots of maize, following the same technique employed for root nodules of legumes, and the bacteriophage thus isolated from maize was found to dissolve the cultures of the berseem and pea nodule organisms. Plaques were also obtained after plating it with the cultures of these organisms on agar. The bacteriophage on maize roots is comparatively less active than the bacteriophage from the root nodules.

V. DAIRY BACTERIOLOGY

The average plate counts of the bacterial content of milk supply are given below with those of the previous two years for comparison: —

Month	Average counts per c. c.			Coli counts 1931-32		
	1929-30	1930-31	1931-32	Days present in 1/100 c. c.	Days absent in 1/100 c. c.	Days present in 1/10 c. c.
July	18,800	5,500	3,833	*nil*	13	1
August	13,300	4,400	4,092	*nil*	12	2
September	17,140	6,700	4,753	*nil*	15	*nil*
October	11,400	2,840	2,333	*nil*	9	1
November	8,200	5,400	3,470	*nil*	15	2
December	5,500	1,840	3,400	*nil*	14	*nil*
January	5,940	2,200	8,845	*nil*	12	2
February	5,700	2,900	4,000	1	9	4
March	12,800	3,565	9,750	*nil*	11	*nil*
April	40,000	3,472	8,617	1	11	5
May	61,200	3,900	5,871	4	10	8
June	5,660	2,664	7,192	1	12	9

The counts of the year, though lower than those of the previous years during the first five months, were higher than the last year's counts in the remaining months despite no change in the hours of milking and milk distribution. Again this year *B. coli* were not found for eight months and were present only on eight days out of 146 days in 1/100 c.c. The highest monthly average count of the year, instead of being recorded in September, was found in March and was 9,750, much below the average count of 30,000 per c.c. allowed in certified milk. Last year the count was only 3,565 in March. Whether this result is due to preponderance of milk of certain cows which show a higher count or whether there is any defect in the arrangements for proper cleanliness of vessels requires to be examined.

Samples of milk stored at 10°C. in the Frigidaire kept good for five days instead of one week as was found last year.

The decrease in counts after storing milk in the Frigidaire observed last year was again found this year. This decrease is attributed to the bactericidal property of fresh milk. This year the period of storage was extended to three or four days more and plates were made on standard agar as well as on purple lactose agar to find out which kinds of bacteria are affected by this property of fresh milk, and it was observed that only the lactic acid organisms were reduced in number.

A few samples of milk were plated using distilled water and saline solution for dilution to find the difference in plate counts. The results obtained showed an increase in counts on five occasions with distilled water and on three occasions with saline solution, while equal counts were obtained once. The grading of milk samples, however, was not affected by the difference in the nature of the diluting fluid.

VI. SILAGE

Following a suggestion of this Section a silage pit was filled in the farm with a mixture of berseem and green oats and opened in May 1932. When examined, the colour of the silage was found to be as good as in the last year and it had a fine smell. Total acidity showed an increase over last year and was 7·74 per cent. on dry basis and the pH of the juice was 5·7.

VII. PRESERVATION OF VEGETABLES

Experiments were undertaken to examine the epiphytic flora of late cabbage and *kakri* (one of the cucurbits) to see whether lactic bacilli were present on them naturally or not, with a view to determine whether they are suitable for storage by addition of salt in preserving jars like cabbage earlier in the season. Lactic bacilli were found to be present on the cucurbit but were not detected on cabbage. Total acidity of juice, however, was raised from 0·18 per cent. to 0·8 to 0·9 per cent. in about a week in both cases,

showing that the epiphytic flora is suitable for preparation of acid products.

Potato storage. Experiments on potato storage showed that potatoes harvested a fortnight or three weeks earlier than the usual time (beginning of March) keep better. Cinders and charcoal again proved the best materials. Potatoes grown after application of different manures have been stored this year to see whether manure has any effect on their keeping quality.

VIII. PLANT DISEASES

A leaf spot of chillies in the seedling stage causing ultimate rotting of leaves and the death of seedlings after defoliation was examined and showed the presence of bacteria in the intracellular tissue of the leaves. The bacteria apparently enter through the stomata. The disease was so far noticed in the seedling stage only and no damage occurred after transplanting. Spraying of badly affected seed-beds with 1 per cent. copper sulphate checked the disease and the sprayed seedlings kept under observation grew well and gave a normal yield. Spraying of cultures of the isolated organisms on leaves did not produce the disease but seeds soaked in the culture of the organism produced seedlings similarly affected in a number of cases.

A stalk rot of sorghum was reported from the Sakrand farm in Sind. The disease appeared to be of bacterial origin but fresh material could not be obtained to make a sufficient number of platings to isolate the organism and carry out inoculations in time.

Diseased plants (maize) received from Muktesar were examined and found to be suffering from stalk rot, the same as was previously found in Pusa and in villages round about Pusa.

Sugarcane yellowing. A few samples of sugarcane from Sepaya suffering from yellowing and drying up of the leaves showed stripes similar to red stripe but the real cause of yellowing could not be located. As the yellowing disappears after heavy showers of rain, it is probable that some physiological condition in the growth of sugarcane may be responsible for this disease.

Tobacco wilt. A disease of tobacco plants was noticed in a village about three miles from Pusa. The chief symptom was the wilting of the plant after the appearance of a blackened patch on the stem a few inches above ground. Examination did not show any bacteria in the black area, but the roots were found to be stunted. Fresh seedlings planted to replace the dead plants also died through a similar cause. The soil taken from the area of the diseased plants did not show any difference either in composition or concentration of salts or in water content. There were two varieties growing; only one of them appeared to be affected and this variety at the time of examination had not any well devolved tap

root but only a cluster of small rootlets. It was suspected that the disease was due to a stunting of roots which may have been caused by a soil organism. So the roots of the seedlings to be freshly transplanted were dipped in a week solution of uspulun. This treatment appears to have succeeded but, as it was tried towards the end of November and beginning of December, it is not certain whether this success is due to the treatment or a change in the season. This will be determined if the disease occurs again sufficiently early before the winter sets in.

IX. PROGRAMME OF WORK FOR 1932-33

Conservation of nitrogen in soil. Conservation of nitrogen is one of the important problems in maintaining the fertility of Indian soils. A series of experiments of growing leguminous crops in mixtures or rotation were started two years back: one adapted to the *kharif* season and the other to the *rabi* season. These will be continued and the variations in total nitrogen in the soil and the economic returns of crops will be examined.

Green-manuring. A large-scale experiment will be made of comparing *urid* and soybean and the application of sann-hemp tops late in the season after removing the stems for fibre, with the usual method of ploughing in sann-hemp.

The experiment with Mexican sunflower will be repeated and a large-scale experiment tried on the farm.

Biological analysis of soils. Biological analysis of the samples of soil from irrigated and unirrigated fields will be continued to find what changes irrigation produces. Biological analyses of other soils will be carried out as occasion arises.

Calcium cyanamide. The decomposition products of calcium cyanamide in different soils which nitrify calcium cyanamide much later than in other soils will be studied.

Bacteriophagy. Search for the bacteriophage from roots of cereals will be continued and they will be studied after their isolation to find what effect they have on the leguminous nodule organisms in soils.

Dairy bacteriology. Quantitative study of bacteria present in general milk supply at Pusa at the time of distribution and in the individual cows with a view to bacterial control of cleanliness in production of milk in the dairy.

Bacteriology of silage. Preparation and study of silage from different lawn grasses and other suitable products like sugarcane tops and mixtures of different crops will be continued.

Other investigations. Study of the preservation of fruits and vegetables by cold storage and the effect of spices in pickles in preventing spoilage will be continued.

X. PUBLICATIONS

Walton, J. H., and Ram Ayyar, C. S.	Catadyn—A new Sterilizer, for use in the Dairy. *Agri and Live-stock in India*, Vol. II, Pt. V, September 1932.
	Notes on the stability of Bleaching Powder and Hypochlorite Solutions. *Agri. and Live-stock in India*, Vol. II, Part III, May 1932.
Desai, S. V. . . .	Studies on Bacteriophages of the Root Nodule Organisms. *Ind. Jour. Agri. Sc.*, Vol. II, Part II, April 1932.
	The Influence of Green Manure and Organic Residues on Nitrogen Fixation in Soil. Accepted for publication in *Ind. Jour. Agri. Sc.*

REPORT OF THE IMPERIAL DAIRY EXPERT

[Zal R. Kothavala, B.Ag., B.Sc., (Agri.), N.D.D.]

I. INTRODUCTION

Mr. William Smith was the Imperial Dairy Expert up to the 25th September, 1931, when he proceeded on leave preparatory to retirement. I assumed charge of the post of Imperial Dairy Expert from the 26th September, 1931. The post I held as Assistant to the Imperial Dairy Expert remained unfilled owing to the present financial stringency and has since been abolished.

The year under review was quite abnormal both from the point of view of the commercial working of the farms and the general administration of the Section. The severe trade depression which prevailed throughout the year affected the receipts of the farms adversely; still the financial position of the farms taken as a whole was more satisfactory than what it was last year. The demand for exercising economy right from the beginning of the year crippled the activities of this Section to a considerable extent.

As a measure of retrenchment the Central Research Creamery at Anand was closed down from the 15th March, 1932, and the work of the Central Bureau of Animal Husbandry carried on under this office was also discontinued from the 21st February, 1932.

The demand made on this office for technical advice and for information on problems relating to the dairy and cattle breeding industries from the general public, local bodies and Provincial Governments continued to be the same as in the past. As the conditions of milk supply in big cities are becoming more acute, greater interest was evinced by local bodies and municipalities in improving the supply of milk. Before this problem could, however, be successfully tackled a great deal of experience and knowledge is still required. This kind of experimental work was conducted at the Research Creamery at Anand, and it is a matter of regret that this institution had to be closed down as a measure of economy.

The general condition of the cattle at all the farms was on the whole satisfactory in spite of outbreaks of bovine diseases of one kind or the other on all the farms. The Karnal farm had rather a prolonged outbreak of foot-and-mouth disease. Due to the water-logged condition of some parts of this farm the trouble from external parasites appears to have an adverse effect on the general health and efficiency of the herd, and it is proposed to counteract this by providing periodic dips to cattle in a diping tank. Except for a mild outbreak of foot-and-mouth disease the Wellington farm was free from virulent outbreaks of bovine diseases such as occurred in past years.

On the cultivation side, the yield of crops on the Karnal farm was greatly affected by the prolonged rainfall which damaged the mature standing *kharif* crop and delayed the sowing of the winter crops. At Wellington the rainfall was more favourable and increased yields of fodder crops were obtained.

Lack of chemical help and other facilities required for carrying out scientific investigations into problems relating to milk and milk products has greatly hampered this kind of work, and a proposal for the appointment of a whole-time chemist for this kind of work has once again been submitted.

II. EDUCATIONAL WORK

Of the 24 students who were admitted as the fourth batch for the Indian Dairy Diploma course in October 1929, twenty passed in the final examination held at Bangalore in December 1931, one of them with Honours. During the year 20 students were selected for the Diploma course and the class was opened at the Imperial Cattle Breeding Farm, Karnal, in October 1931.

Two candidates admitted for a post-graduate course in animal husbandry and dairying in January 1931 also completed their training in March 1932. Due to the uncertainty prevailing regarding the retention of the Dairy Institute no fresh post-graduate students were admitted in January 1932 as was done in the past.

Three students attended short courses of practical training in dairying at the Bangalore, Wellington and Karnal farms, and one Veterinary Surgeon deputed by the Hyderabad State had a further six months' advanced training at the Institute after passing his Indian Dairy Diploma examination. Twenty-seven British soldiers were admitted to the Bangalore Institute for vocational training for a period of six months.

At the request of the Imperial Council of Agricultural Research, this office submitted a detailed syllabus of a practical dairying course to be imparted in vernacular in various provinces to milk producers and small dairy farmers.

III. EXPERIMENTAL AND RESEARCH WORK

Karnal Farm. Further research on the breeding of Hariana and Tharparkar cattle on dual purpose lines for draught and milk was continued, as also the work of improving the wool of Bikaner sheep in quality and quantity by systematic breeding and feeding of the flock.

Bangalore Farm. Work in the economic rearing of calves by weaning and hand feeding in the case of Indian breeds of cattle was continued at Bangalore and at its substation at Wellington. Experimental work for ascertaining the efficiency of pasteurisation by different kinds of machines was conducted. Also investigation into the problem of treating purchased cream for improved flavour and keeping quality of butter was continued.

Anand Creamery. Problems of transporting milk over long distances and the most suitable methods of treating milk before despatch for distant markets, were tried.

IV. ADVISORY WORK

More than seventy references from localities in almost all provinces in India were answered regarding various aspects of dairying and cattle breeding and literature thereon and information was supplied to correspondents in Ceylon, Federated Malay States, Australia, Nairobi, Barbados, New York and England. At Karachi Mr. Smith purchased three buffaloes for the Bangalore Institute and selected ten Murra buffaloes as a foundation herd for the new cattle farm in the Hyderabad State.

V. CO-OPERATION WITH OTHER SECTIONS

The Physiological Chemist's Section was provided with the necessary number and type of young cattle and other facilities for starting an experiment on mineral feeding.

An important experiment of a long duration was planned out with the Physiological Chemist and started at the beginning of this year, with a view to find out the effect of a ration with an abnormal quantity of protein on dairy cows.

VI. PUBLICATIONS OF THE YEAR

(1) A note on the scientific and experimental work done by this Section was sent, at his request, to the Secretary, " Current Science ", a monthly scientific journal published from Bangalore.

(2) A paper on " Neutralization and pasteurization of sour cream ", by Mr. S. Cox (*Agri. and Live-stock in India*).

(3) A paper on " Milk production in India " by Mr. Zal R. Kothavala, read by him before the Tropical Section of the 9th International Dairy Congress at Copenhagen (*Agriculture and Live-stock in India*).

VII. ADMINISTRATION OF FARMS AND CREAMERY

The main features regarding the working of the farms and creamery have already been commented on in the introductory para. of this report. The following are detailed reports from the Superintendents of the farms:—

Karnal

On Mr. F. E. Traynor proceeding on leave from 16th June, 1931, Mr. A. A. Lamb took over and remained in charge till the end of the year.

Of the 2,154 acres (the original extent of the farm), 30 acres have been handed over to the Sugarcane Sub-station and 143 acres to the Botanical Sub-station of Pusa, leaving 1,981 acres of farm land in use or from which revenue can be obtained. This was utilized approximately as follows:—

	Crops	Acres
Home cultivation	2	156
Home ,,	1	185
Home ,,	1	191
Batai cultivation	1	
Batai ,,	1	173
Batai ,,	2	635
Cash rental		144
Grazing areas		240
Buildings, roads, etc.		144
	TOTAL	1,981

By the reduction of the farm area to the extent of 173 acres a fair amount of revenue has been lost to the farm, particularly as the land in question was very favourably situated.

The crops grown were (1) sorghum followed by gram, (2) early rice followed by gram or peas, and (3) wheat grown in winter after summer fallow.

Sorghum did very well in most plots and was used mainly for silage. The rice had reached the stage for cutting and was a fine upstanding crop when heavy rains laid it low. This both delayed the cutting and caused a decrease in the quantity and quality of the crop. Gram sowing was consequently late and as there were no winter rains at all the gram harvest was not so good as was expected.

Two types of wheat were grown, Pusa 114 and Punjab 8A, and although not harvested until after the close of the financial year it is considered of interest to compare the two in this report. The Pusa 114 variety grew well but it was found to shed a large quantity of the seed in the field very quickly and this could not be recovered. Even so the outturn per acre of seed was 19 mds. as compared with 18 mds. of 8A Punjab, but the price realized in the open market for the former was less by 4 annas a maund than that of the Punjab variety. Another variety of Pusa wheat will be given a trial in the next sowing.

The strength of the live-stock of the farm at the beginning and the end of the year was as follows:—

	1st April 1931	31st Mar. 1932
Bulls	10	6
Cows	192	126
Buffaloes	32	13
Cow, young stock—		
Female	164	101
Male	170	109
Buffalo, young stock—		
Female	34	23
Male	11	9
Bullocks	72	24
Rams	10	6
Ewes	77	93
Lambs	156	139
Horse	1	1
TOTAL	929	650

The large reduction in numbers was due to general retrenchment towards the end of the year.

One hundred and ninety-one cow and 31 buffalo calves were born and 51 cow and 7 buffalo heifers calved during the year.

There was a long and troublesome outbreak of foot-and-mouth disease lasting from October 1931 to February 1932, during which time 565 actual cases occurred. There were, however, no casualties. Apart from this the health of the live-stock of the farm was very satisfactory, the deaths from ordinary causes being as follows:—

Cows	Bulls	Young stock	Calves	Bullocks	Sheep
5	2	3	14	2	21

The average daily milk yields for the year were as follows:—

	Over-all milking herd	Over-all average
	lb.	lb.
Tharparkar	11·3	7·75
Hariana	11·65	7·6
Murra buffaloes	13·55	10·51

The six best animals of each breed to complete their lactations during the year gave the following yields:—

No.	Animal No.	Age	Yield during 1931-32 in lb.	Days in milk	Remarks
		Yr. M.			
	Tharparkars				
1	306	5 6	6,446	458	Farm bred.
2	216	8 4	5,466	428	Do.
3	119	13 0	5,253	422	
4	347	4 10	5,100	417	Farm bred.
5	251	7 2	4,739	304	Do.
6	323	5 11	4,686	269	Do.
	Harianas				
1	302	7 1	7,412	344	Farm bred.
2	186	8 8	5,476	252	
3	242	7 5	5,458	347	Farm bred.
4	270	9 0	5,232	316	
5	137	11 6	5,176	295	
6	383	4 5	4,298	305	Farm bred.
	Buffaloes				
1	13	12 0	6,410	462	
2	25	10 0	5,908	512	
3	10	12 0	5,717	321	
4	33	5 10	5,465	288	Farm bred.
5	19	11 0	5,437	229	
6	42	5 10	5,270	416	Farm bred.

Seventy-six animals were inoculated by the serum simultaneous method against rinderpest in March 1932 by a member of the staff from Muktesar, a number showing symptoms of piroplasmosis which was treated by the usual trypan-blue injections.

The disposal of milk or its products still remains a problem. The low local market rate precludes our selling to the public at Government sanctioned rates and the only alternative then is to separate the cream and sell to the Military Farms Department on the butter outturn, feeding the surplus separated milk to live-stock. When however the Military Farms did not require as much cream as the farm produced, recourse had to be made to *ghee* manufacture which proved unremunerative owing to the low rate for *ghee* in the local districts. 421 lb. of Cheddar cheese was manufactured during the cold weather for the benefit of students.

Students. Twenty Diploma students joined in October 1931. In addition, three short-course students and two post-graduate students spent periods varying from one to $2\frac{1}{2}$ months each.

The farm was visited during the year by His Excellency Sir Geoffrey de Montmorency, Governor of the Punjab.

Bangalore

Mr. Cox assumed charge of the farm on the 30th May, 1931, and remained in charge throughout the year.

Lands and Cultivation. The outturn of cultivated fodder crops was 24,97,530 lb. during the year. The over-all production cost per 100 lb. was Rs. 0-3-9 as compared to Rs. 0-3-0 of the previous year. This increase in cost is due to insufficient rain which reduced the water available for irrigation purposes.

Herd. The yields of the six principal cows in the cross bred and Scindi groups are shown in the following table:—

Cross-Bred Cows

Serial No	Number of cows	Date of birth	No. of calving	Quantity of milk given in lb.	No. of days in milk	Remarks
1	353A	9-11-1921	6	12,071	337	$\frac{3}{4}$-bred.
2	359A	3-1-1922	10	6,527	300	Half-bred.
3	388A	27-8-1922	10	6,224	316	H. B. × H. B. (F_2)
4	398A	7-1-1923	9	6,403	361	Do.
5	417A	8-8-1925	7	7,425	312	H. B. Holstein-Scindi.
6	420A	2-10-1925	$6\frac{1}{2}$	11,379	306	Half-bred (4th lactation).

Scindi Cows

Serial No.	Number of cows	Year of purchase and present approximate age		No. of calving since arrival	Quantity of milk given in lb.	No. of days in milk	Remarks
		Year	Age				
1	111	1927	12	4	4,205	245	Farm bred.
2	127	1928	15	3	4,727	329	
3	142	1928	11	3	4,820	266	
4	148	1928	11½	3	4,518	397	
5	212	1927	4½	1	4,000	326	
6	213	1928	4	1	4,796	373	

There were outbreaks of rinderpest and anthrax among young stock during the year at the Bommanpally dry stock farm but only 14 deaths, *i.e.*, two due to anthrax and 12 due to rinderpest.

During the year the farm herd produced 657,580 lb. of milk, out of which 360,793 lb. were sold to military hospitals, officers and troops, and 183,044 lb. were separated which gave 14,614 lb. of cream. Of this cream, 3,298 lb. were sold as such and 11,293 lb. were converted into butter, the outturn being 6,769 lb. 16,666 lb. of milk were issued for the manufacture of cheddar cheese, the outturn being 1,404 lb. 168,430 lb. of separated milk were produced, of which 162,738 lb. were issued for feeding the calves, 4,912 lb. sold, and out of the balance a certain quantity was used as starter for cheese making, etc.

Breeding Policy. The breeding policy remained unchanged:—

1. The best Scindi cows were bred to selected Scindi bulls.
2. Other Scindi cows not typically pure were bred to imported Ayrshire and Friesian bulls.
3. Half-bred cows were bred to Friesian bulls.
4. Three-fourth bred cows were bred to pure Scindi pedigreed bulls.

It is hoped that in future years we will be able to replace all cross-bred cows by Indian cows of known breeds.

Education and Research Work. At the beginning of the year there were four post-graduate students and three short-course students. In October 1931 one short-course student from the Kashmir State joined the Institute for a six-month course.

Twenty-four Indian Dairy Diploma students of the previous year continued their training up to December 1931 and at the final examination held at this Institute 20 were successful. In January 1932 one post-graduate student from the Agricultural Department, Hyderabad (Deccan), joined the Institute. Twenty-seven British soldiers joined the Institute for vocational training. His Highness the Maharaja of Bhavnagar visited the Institute, as did also a large number of interested persons.

Wellington

Mr. E. G. Whittick was in charge of the farm up to the end of January 1932, Mr. Mohamed Naziruddin Jeddi for February 1932, and Mr. M. C. Rungaswamy for the remaining period of the year.

The rainfall during the monsoon of this year is compared with the previous year as follows:—

	1931-32	1930-31
June	4·39	1·67
July	5·74	1·23
August	3·46	3·23
September	5·68	3·73
	19·27	9·86

As the rainfall during 1931-32 was 9·41 inches more than that of the previous year there was an appreciable increase of 268,740 lb. in the outturn of green fodder during this year as compared with last year as detailed below. The decrease in the outturn of potatoes, *i.e.*, 18,920 lb. is due to the second crop having met with a bad disease which affected the root just before harvest time. The plants looked healthy to all appearances, but when dug out the potatoes were diseased and decayed.

	1931-32 lb.	1930-31 lb.	Comparative Increase lb.	Comparative Decrease lb.
Green fodder .	678,690	409,950	268,740	...
Potatoes . .	38,090	57,010	...	18,920
	716,780	466,960	268,740	18,920

The yields of different crops obtained during this and the previous year are as shown below:—

	1931-32	1930-31
	lb.	lb.
Green maize	118,210	20,800
,, sorghum	52,125	116,710
,, oats	260,915	138,790
,, grass	177,110	116,020
,, bedding	11,540	11,155
,, lucerne	...	6,475
,, cabbage	14,285	...
,, *ragi* (*E. coracana*)	32,435	...
,, *bajri* (*P typhoideum*)	12,070	...
	678,690	409,950
Potatoes	38,090	57,010
	716,780	466,960

The policy of the farm is to produce as much fodder as possible to supplement purchases.

Herd. The different classes and breeds of animals maintained in the herd were as follows:—

Ayrshire cows	11
Jersey cows	1
Ayrshire—Jersey	1
,, Scindi	21
,, Hansi	2
,, Sahiwal	10
,, Tharparkar	1
,, Sc. Sahiwal	7
Half-bred × Half-bred	1
3/4 Ayrshire—Jersey	1
,, Scindi	2
,, Hansi	1
Holstein—Hansi	2
Scindi	1
Hariana	12
Sahiwal	1
Ayrshire—Hansi—Sahiwal	2
3/4 Ayrshire—Scindi—Sahiwal	2
1/4—bred	1
	80

A mild attack of foot-and-mouth disease occurred during August and September 1931. Four cows, three bulls and 16 young stock were affected. Necessary precautions were adopted to prevent the disease. Except for this, the cattle were all healthy during the

year under review. One Ayrshire bull and 49 cross-bred cows were sold by public auction in the middle of March 1932 due to measures adopted for economising the expenditure and reduction of the farm herd to the lowest limit under the new scheme of running the farm. The yields of six pure-bred and six cross-bred cows obtained during the year 1931-32 were as under:—

No. of cow	Yield	No. of days in milk
	lb.	
	Pure-bred Cows	
21	7,622	312
16	7,070	300
19	6,977	368
17	6,914	451
20	6,301	419
7	4,067	343
	Cross-bred Cows	
259	10,871	607
237	10,401	408
99	9,169	411
119	7,536	386
100	6,367	404
199	6,124	415

The yields noted above are not comparable with those of the previous two years due to the herd being affected with foot-and-mouth in 1929-30 and foot-and-mouth and rinderpest during 1930-31.

The value of dairy produce sold during 1931-32 was Rs. 70,853 against Rs. 77,275 during 1930-31.

	1931-32		1930-31	
	Lb.	Amount Rs.	Lb.	Amount Rs.
By sale of—				
Milk . .	232,282	45,661	248,064	48,211
Butter . .	19,567	24,472	19,329	28,108
Cream . .	310	543	434	760
Cheese . .	41	68	72	126
Butter milk .	...	...	117	2
Separated milk .	...	...	146	9
Sundry credit for odd ounces of milk and butter	...	109	...	59
		70,853		77,275

Anand

The Anand Creamery continued working till the 15th March, 1932, when it was finally closed down under orders of the Government of India as a measure of retrenchment. The financial position of the creamery was not as favourable as it was last year, as the total realizations for 1931-32 were Rs. 39,677 as against Rs. 76,994 in 1930-31. This was mainly due to the trade depression which brought about a considerable fall in the sales of butter and other produce and to the anticipated closing down of the creamery to effect economy which prevented further business being secured. There was practically no demand for casein in the market and the prices fetched by it did not make it worthwhile manufacturing the product, so separated milk had to be disposed of at any price offered by the market and when not in demand had to be thrown away.

The prevailing uncertainty about the continuance of the creamery also prevented any experimental work being planned and the work in connection with the transport of milk over long distances started in co-operation with the Bombay Municipality in the beginning of the year had to be discontinued.

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